AN EX-ANTE IMPACT ASSESSMENT

OF TRAVEL TIME, ACCESSIBILITY AND COMPETITIVENESS

OF STAVANGER CITY CENTER

A MASTER'S THESIS
IN

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To my friends and family, thank you for believing in me, especially when I didn't believe in myself. You are the real MVPs – Thank you!

ABSTRACT

This thesis is an exploratory study and an ex-ante impact assessment of specific proposed plans outlined in the municipal sub-plan (Stavanger Kommune, 2019) on travel time, accessibility, and competitiveness of Stavanger City Center in a spatial analysis context. The goal of the thesis was to attempt to answer the following questions:

How will the new municipal sub-plan impact travel time and car accessibility for visitors driving to Stavanger City Center? And how will it affect the competitiveness of the city center?

The analysis results were derived from a technical geographic information systems (GIS) network analysis and revealed that visitors driving to the city center will see a one- to two-minute increase in travel time after the implementation of the recommended plans in the municipal sub-plan. Visitors originating east of the city center (including Hundvåg) saw the smallest increase in travel time of up to one minute, while the rest saw an increase in travel time of up to two minutes. Due to accessibility's complex definition, this thesis could only conclude on travel time as part of the transportation component of accessibility. The analysis results also showed a reduced catchment area where a portion was lost to Kilden and Madla; however, attempting to predict a possible change in people's shopping behaviors based on the findings of this thesis was impractical, and it was concluded that the vitality of the city center provides a competitive advantage that realistically ought to outweigh the effects of the increased travel time.

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1. INTRODUCTION

The transition towards walkable urban neighborhoods and transit-oriented cities is often a worthy endeavor fueled by public health- and environmental goals. The opportunities and challenges preceding and following such an endeavor are many, and generally demand sacrifices for the greater good. Being aware of the effects of local policies, plans and projects, is naturally a part of this transition and crucial in city and regional planning.

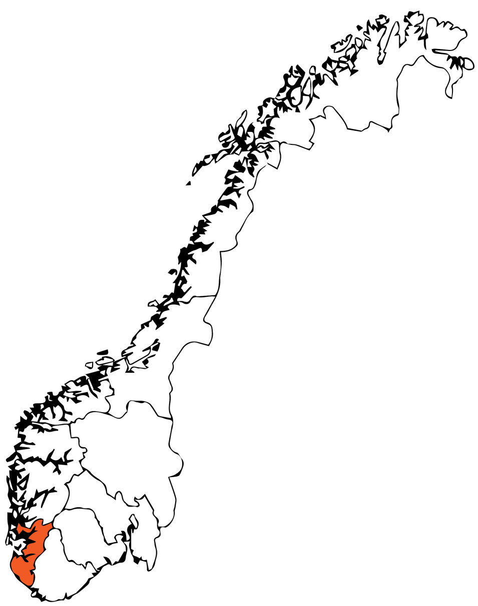
Transportation is an essential function of society, and it impacts arguably every aspect of our lives. The land use of today is generally a reflection of the transportation system it has been built on. Going from a low-density, car-dependent landscape to a system favoring walkability, cycling and public transportation while de-prioritizing personal vehicle use through toll roads and restricting road access is a situation which offers its fair share of challenges, yet one deemed necessary for the protection of the vulnerable environment the society so heavily depends on.

The city center of Stavanger is adapting to the needs of people and the environment which requires a shift in how we live, work and play. This inevitably involves how we move to and about the urban landscape, and every traffic group (pedestrian, cyclist, motorist, transit user) and stakeholder (business owners, homeowner associations, interest groups, etc.) experience this transition differently. The focus of this thesis is on the impact that aspects of this transition has on travel time, car accessibility, and economic competitiveness.

1.1 Case: Stavanger

The municipality's focus on smart growth and environmentally friendly travel to, from and within Stavanger city center (Stavanger Kommune, 2019) is evident in the recently adopted municipal sub-plan for the city center which includes changes to the current road network. The impact these changes can have on travel time, accessibility and potentially competitiveness should be of considerable interest to stakeholders. It could affect Stavanger's role as the region's most important city center, and potentially affect the competition with commercial agglomerations on the outskirts of the city center.

1.1.1 Background



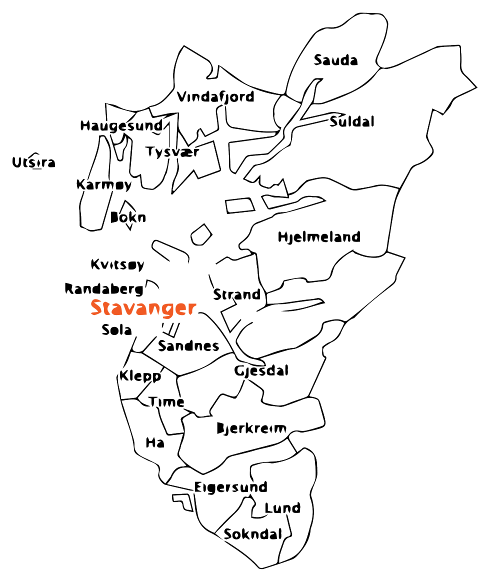


Figure 1.1–Map of Norway with Rogaland highlighted (Own figure)

Figure 1.2–Map of Rogaland with Stavanger (Own figure)

Located in the southwest region of Norway (*figures 1.1 & 1.2*), Stavanger and Sandnes municipalities form one of Norway's most populous urban areas with a combined population of 224,000 (Statistisk Sentralbyrå, 2021) and Stavanger is the administrative, economic and cultural center of Rogaland county (Stavanger Kommune, 2021). Stavanger has a quaint walkable city center situated right by the water and is often characterized by its wooden buildings as pictured in *figure 1.3*.

Figure 1.3–Marketplace at Vågen in the city center of Stavanger (source: Stavangersentrum.no)

The Stavanger region is an area of mostly low-intensity development serviced by car roads, bike routes, and a public transportation system. Stavanger has a network of public transportation corridors that are the basis for the municipality's city development strategy (Stavanger Kommune, 2014). Although dated, *figure 1.4* shows the coverage of these transit corridors from 2014. *Figures 1.5 & 1.6* show biking- and walking distances in the city.

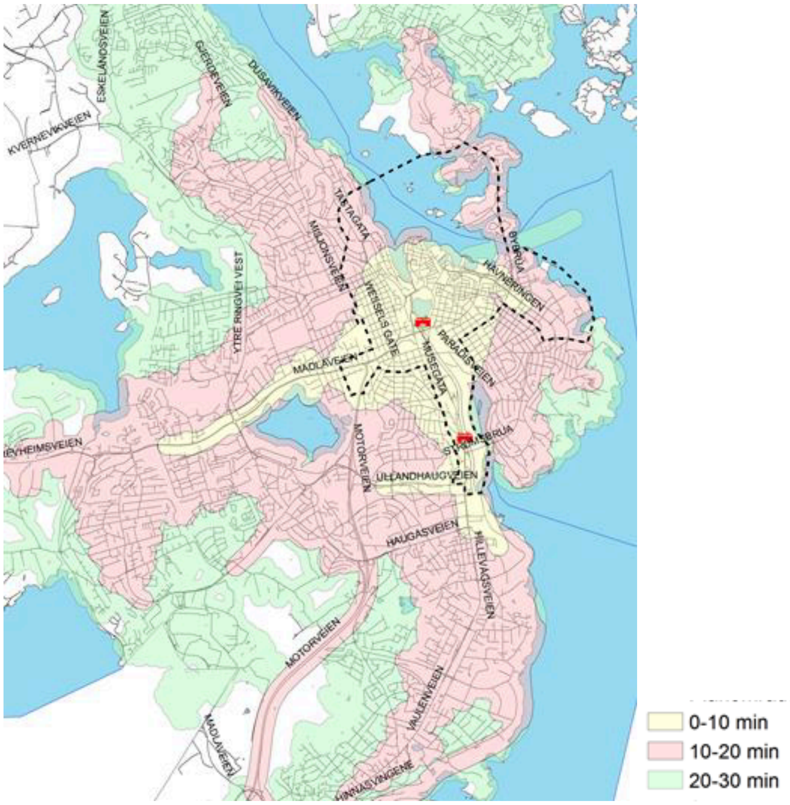


Figure 1.4–Transit coverage in Stavanger (Stavanger Kommune, 2014)

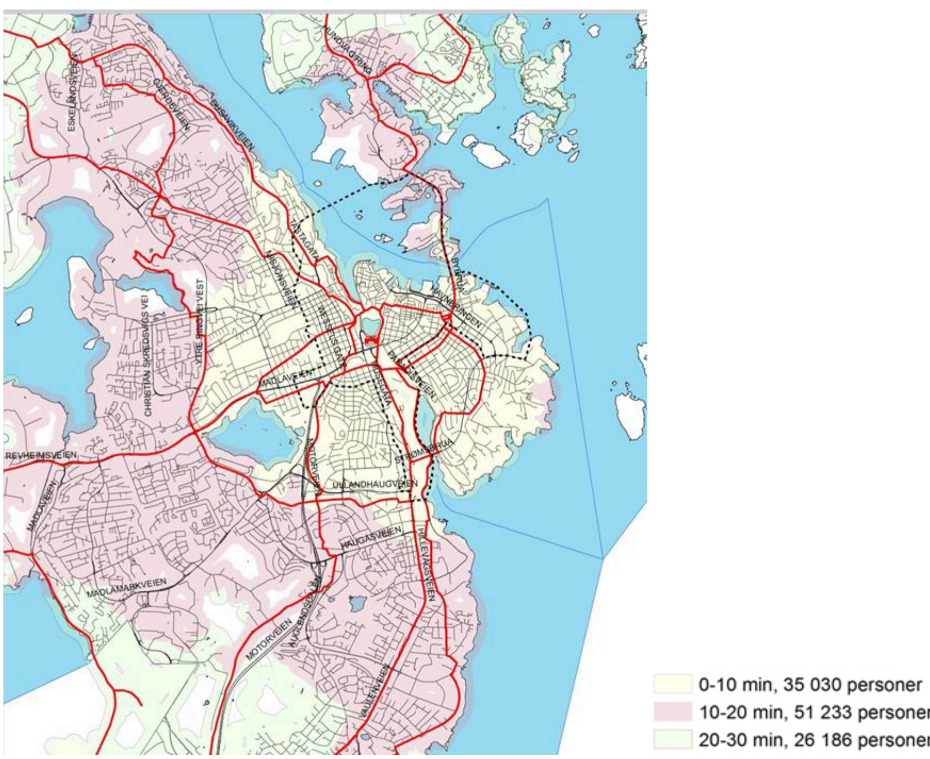


Figure 1.5–Biking distances in Stavanger (Stavanger Kommune, 2014)

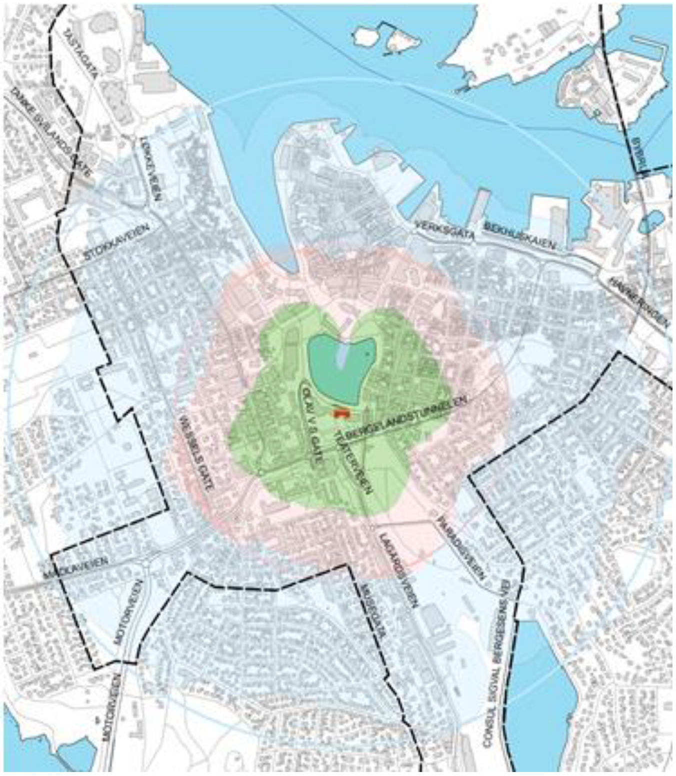


Figure 1.6–Walking distances of 300, 500 and 1000 meters (Stavanger Kommune, 2014)

Figure 1.7 shows the density for Vågen (on the left), a central neighborhood in the city center, compared to Grünerløkka in Oslo (in the middle), and Vesterbro in Copenhagen (on the right. To compare, Vågen has a building mass of 300,000 square meters, while Grünerløkka and Vesterbro have 800,000 and 1,200,000 square meters respectively (Stavanger Kommune, 2014).

Figure 1.7–Density comparison with Oslo and Copenhagen (Stavanger Kommune, 2014)

The “urban belt” shown in *figure 1.8*, also known as “bybåndet” (Stavanger Kommune, 2019), defines the north-to-south urban corridor that connects Stavanger to Sandnes and holds approximately 55 percent of the region’s residents (Stavanger Kommune, 2019).

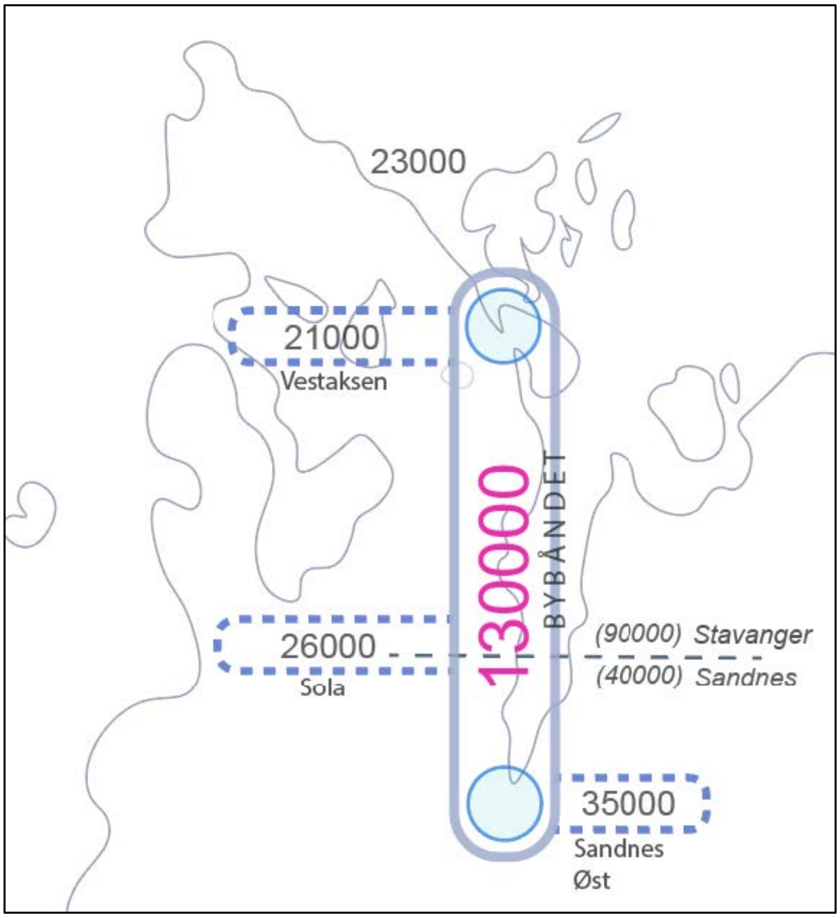


Figure 1.8–Bybåndet / “The Urban Belt” (Stavanger Kommune, 2019)

As a regional center, Stavanger attracts visitors that, according to a 2016 study, generate an estimated total of 130,000 daily trips to and from the city center (Stavanger Kommune, 2019). About half of these trips originate from areas south of the city center, 60 percent of trips to the city center are less than three kilometers, and 46 percent of trips to the city center were made by car (Stavanger Kommune, 2019).

The municipality expects the number of daily trips to increase to more than 200,000 after the municipal sub-plan is implemented (Stavanger Kommune, 2019). Given that almost half of all trips are made by cars in the region, it is important to consider the impact the municipal sub-plan might have on the trips made by personal vehicles.

Figure 1.9–The "city zones" of Stavanger (Stavanger Kommune, 2021)

Stavanger municipality has four "city zones" (A, B, C, D). These zones (*figure 1.9*) have different levels of urbanity; A being the most dense, and D being the least dense. Zones B and C are considered "city development axes"; B being the primary development axis, and C being the secondary development axis. The municipality recommends that 80 percent of the city development happen within zones A and B (Stavanger Kommune, 2021).

1.1.2 Municipal Sub-Plan

The municipal sub-plan, often referred to as "Sentrumsplanen" in the planning document itself, was adopted in 2019 and is the municipality's plan for the city center of Stavanger. It includes plans intended to strengthen Stavanger city center's role as a regional hub for cultural and economic activity and prioritizes access to public transit and other soft modes of transportation.

Accessibility is outlined in the plan as one of the three part-goals to strengthen Stavanger's regional attraction and support the main goal of "being the region's most important city center and meeting place for residents and visitors" (Stavanger Kommune, 2019). Encompassed in the accessibility goal is the focus on "green mobility" to, from and within the city. As a part-goal, accessibility embraces streets and urban spaces that are friendly to soft modes of transportation, such as walking and biking, as well as public transit. The municipality has a goal to have at least 70 percent of trips happen by foot, bike, or public transit (Stavanger Kommune, 2019).

The municipal sub-plan includes concrete plans to change road priority, parking allocation, and increase the number of public space plazas (see *Appendix* for a list of projects). The plans are in various stages of implementation and are not intended to be implemented all at once for practical reasons. The order in which these projects are implemented is subject to the recommendation of the municipality and final decision made in collaboration with the Municipal Committee.

Figure 1.10–A rendering of what Klubbgata could look like (Stavanger Kommune, 2020)

These projects outlined in the municipal sub-plan have been mapped below (see *figure 1.11*) to show which traffic group is given priority for each stretch of road project in the plan. *Figure 1.10* is a rendering showing what Klubbgata could look like.

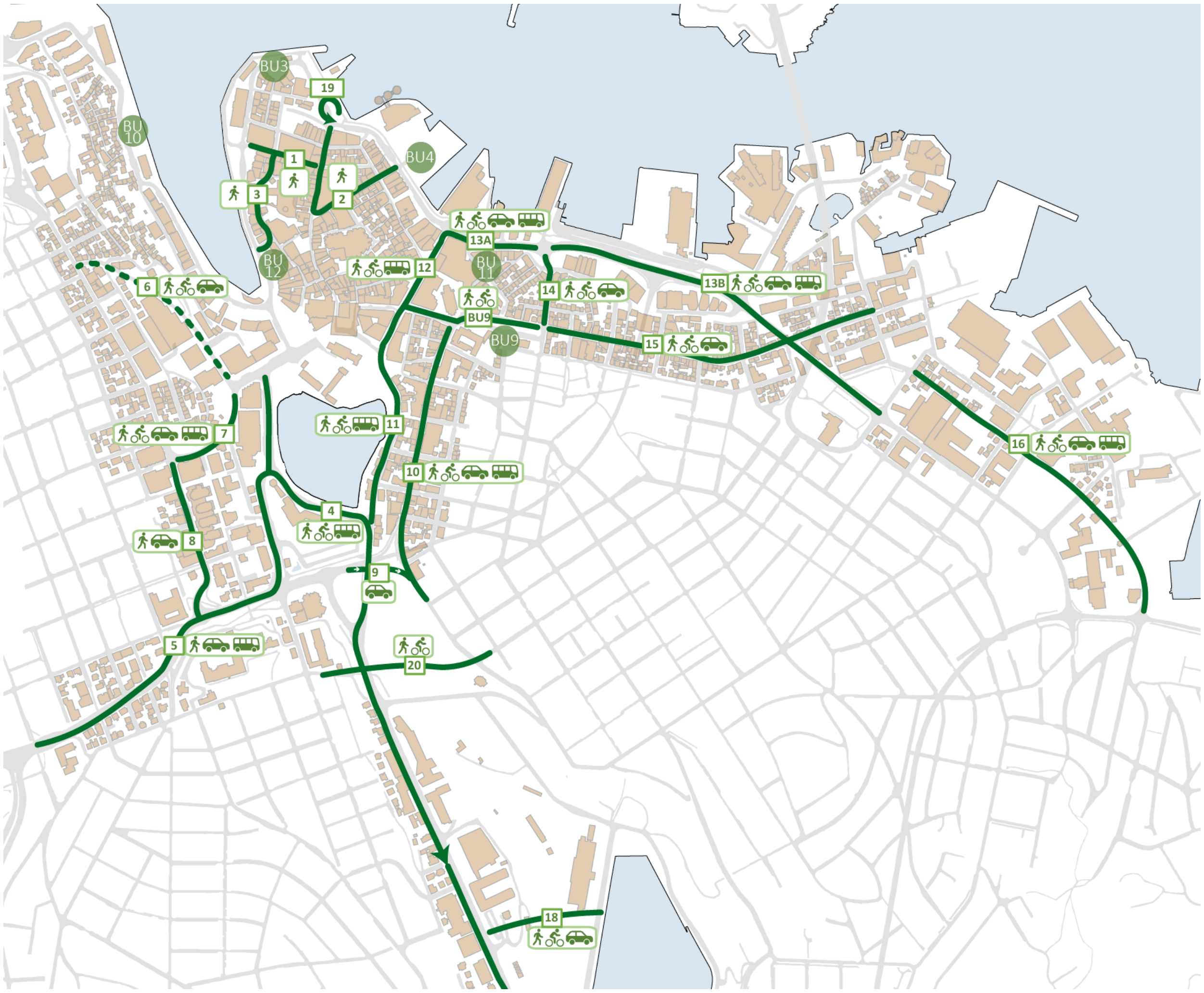


Figure 1.11–Map of the proposed projects in the municipal plan (Own figure)

Although the plan for the city center aims to improve travel for pedestrians, cyclists, transit users and motorists, the only traffic group whose priority has been limited, is the motorist. Since it is only realistic to assume that some people find themselves in circumstances where they depend on a personal vehicle for essential- and leisure travel, it is important to try to map out the consequences for this traffic group. *Figure 1.12* shows the consequences of the recommended projects in the municipal plan for cars. Personal vehicle use in the city center will be considerably limited to prioritize public transit lanes, bicycle lanes, and pedestrians.

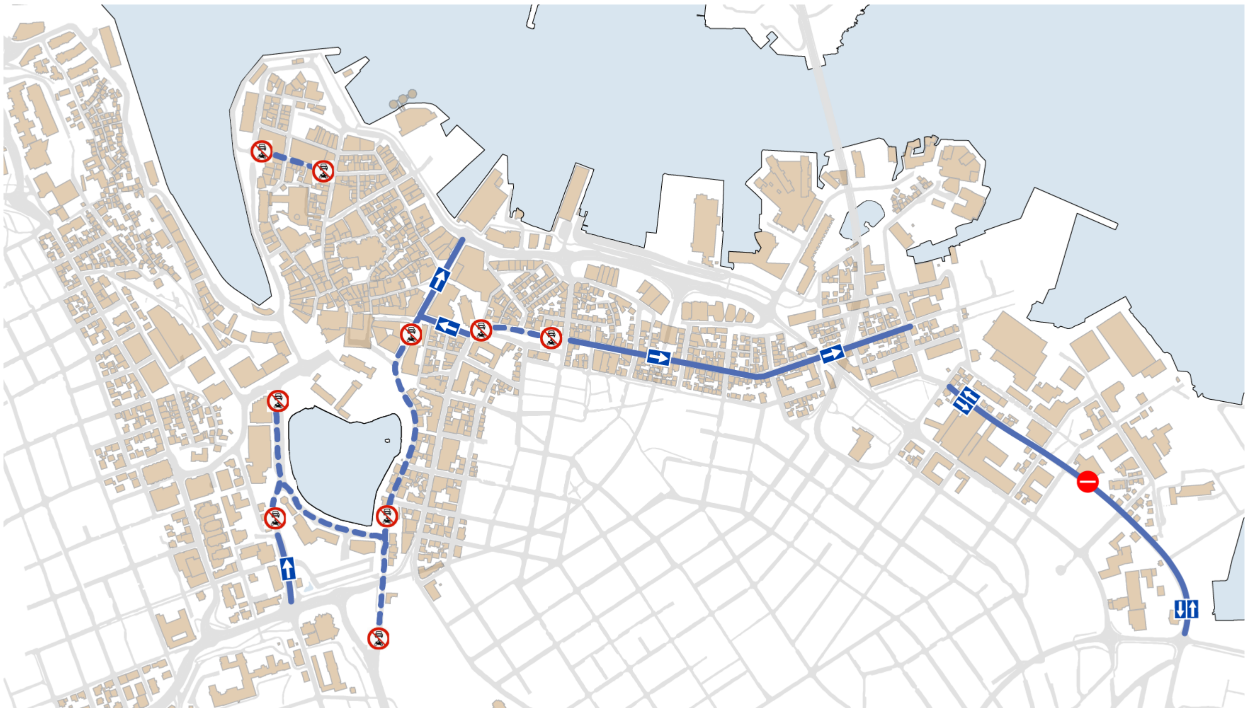


Figure 1.12 Consequence map for cars based on the recommended projects (Own figure)

1.1.3 Significant Locations

The thesis discusses three locations that play a role in answering the thesis questions and in performing the analysis. These locations were picked because of their role as commercial agglomerations with proximity to the city center and are mapped in *figure 1.13* and further described in this *section.* This section also includes numbers from specific postal codes in Stavanger that are highlighted in *figure 1.14*. Stavanger consists of nine municipal areas, seven of which are shown in the map below (*figure 1.15*) for reference for the rest of the thesis.

Figure 1.13–Map of significant locations: Arkaden, Madla and Kilden (source: kommunekart.com)

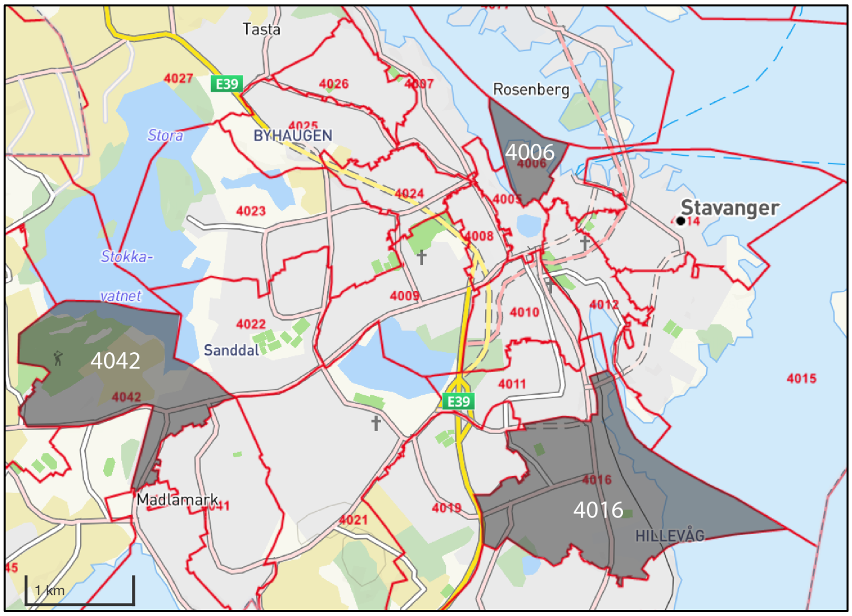


Figure 1.14–Map of significant postal codes (source: kommunekart.com via https://www.stavanger.kommune.no)

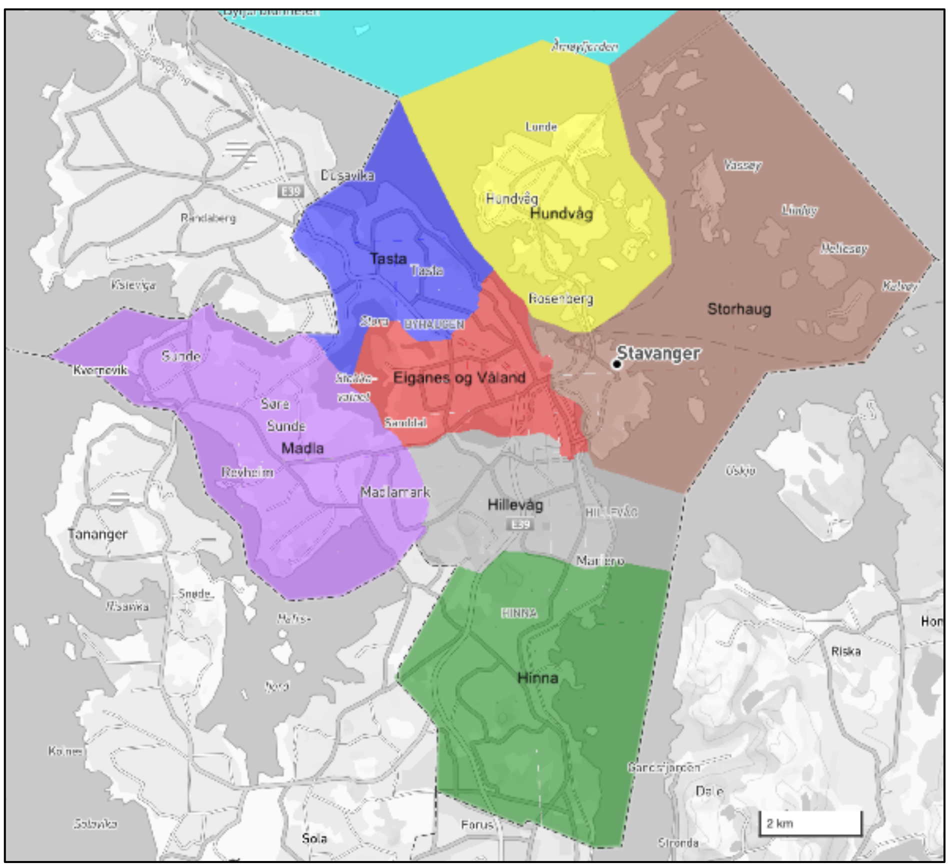


Figure 1.15–Municipal areas in Stavanger (source: kommunekart.com via https://www.stavanger.kommune.no)

Arkaden Parking is a centrally located parking facility in Stavanger City Center with 70 parking stalls (Arkaden Torgterrassen, 2021) operated by Arkaden Torgterrassen shopping mall. Arkaden Parking is accessed from Klubbgata (marked in orange in *figure 1.16*) which is a significant public transportation street in Stavanger. Arkaden Torgterrassen (pictured in *figure 1.18*) is the largest mall in the city center (Arkaden Torgterrassen, 2021) in addition to being surrounded by everything else the city center has to offer, from public spaces and pedestrian shopping streets, to numerous cafes, restaurants and other services. *Figure 1.17* shows the categories and number of businesses in a central city center postal code of 4006. *Figures 1.19 to 1.21* give an indication of the urban setting of Arkaden and its connection to the city center.

Figure 1.16–Map of city center highlighting Klubbgata and Arkaden Parking (source: kommunekart.com)

Employees and businesses in post number 4006 (Stavanger City Center)

Ansatte og virksomheter - Velg postsone(r) i kartet

Hovedgrup..	Gruppering		Number of employees Antall ansatte	Number of businesses Antall virksomheter -
47	Dagligvare	Groceries	111	17
	Klær, sko og vesker	Clothes, shoes, purses	352	55
	Sport, spill, leker og bøker	Sports, games, toys, books	116	13
	Annen utvalgsvare	Other	276	52
	Møbler og elektro	Furniture and electronics	82	6
	Jernvare/Fargevare og annen byggvare	Hardware/paint, etc.	2	2
55	Annen overnatting	Other hospitality	0	1
	Hoteller	Hotels	122	6
56	Barer	Bars	374	23
	Restauranter	Restaurants	1,251	75
96	Personlig tjenesteyting	Personal services	86	55

Figure 1.17–Businesses in Stavanger City Center (source: SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

Figure 1.18–Photo of Arkaden from Klubbgata (Arkaden Torgterrassen, 2021)

Figure 1.19–Østervåg shopping street in the city center (source: https://rydningholding.no/prospekt/ostervag-17/)

Image capture: Jul 2017 © 2021 Google

Figure 1.20–View of Arkaden Parking entrance from Klubbgata (source: maps.google.com)

Imagery ©2021 Google, Imagery ©2021 CNES / Airbus, Maxar Technologies, Map data ©2021 50 m

Figure 1.21–Satellite view of a part of the city center of Stavanger (source: maps.google.com)

Arkaden Parking is the destination location for the analysis of this paper because it represents one of the central areas that will be directly affected a series of road network changes with the implementation of the municipal sub-plan. According to a survey put on by Arkaden Torgterrassen, 21 percent of its customers drive to the shopping mall (Steen & Strøm, 2018). This means that a significant portion of visitors to this mall either depend on a car or choose to travel by car and will therefore be affected by the road network changes. These changes could have significant impact on local traffic patterns, which in return could affect the customer base of Arkaden Torgterrassen.

Visitors enter the city center from four directions. The following maps (*figures 1.22-1.25)* show preferred routes to Arkaden Parking before and after project implementation. The red dashed lines represent routes that are generally preferred today, but that will not be available after project implementation.

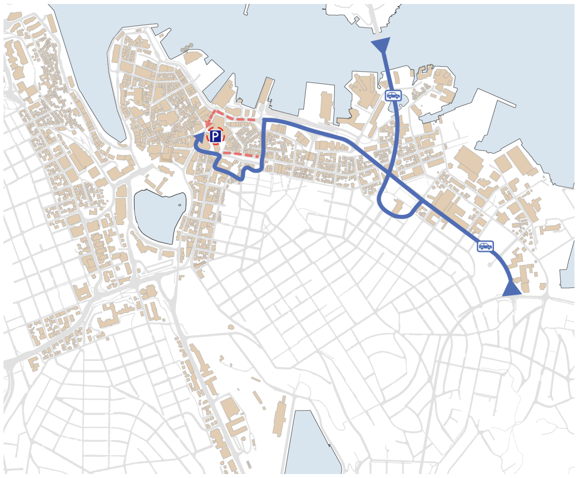


Figure 1.22 Routes from east (own figure)

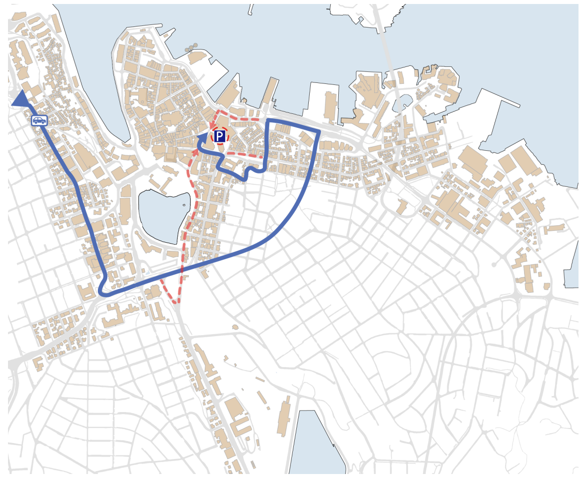


Figure 1.23 Routes from north (own figure)

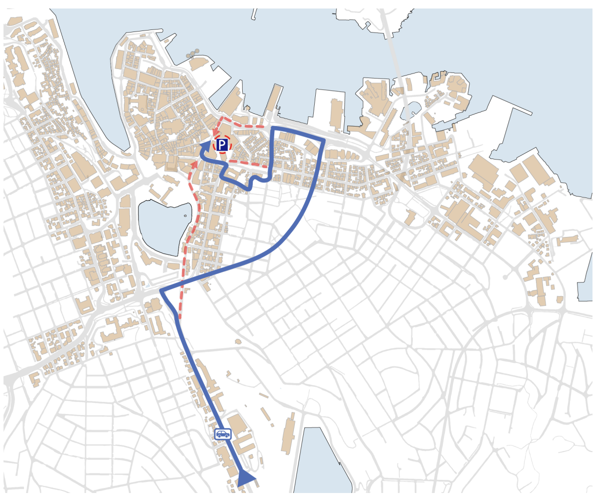


Figure 1.24 Route from south (own figure)

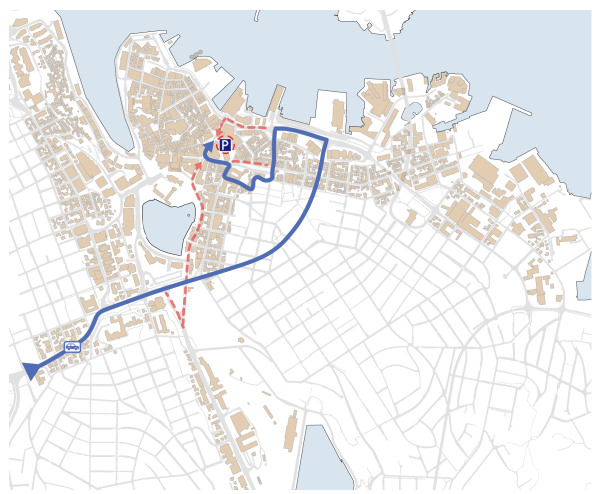


Figure 1.25 Routes from west (own figure)

Kilden is a mall located just 2.5 kilometers south of the city center in the Hillevåg borough. The mall has 60 stores over 15,000 square meters of shopping area, and 350 parking stalls (Kilden Kjøpesenter, 2021). *Figure 1.26* shows the number of businesses in the 4016 postal code in Hillevåg where the mall is located. (See *figure 1.14* to see where).

Employees and businesses in post number 4016 (Hillevåg)

Ansatte og virksomheter - Velg postsone(r) i kartet

Hovedgrup..	Gruppering		Number of employees Antall ansatte	Number of businesses Antall virksomheter -
47	Dagligvare	Groceries	131.0	15.0
	Klær, sko og vesker	Clothes, shoes, purses	142.0	21.0
	Sport, spill, leker og bøker	Sports, games, toys, books	37.0	11.0
	Annen utvalgsvare	Other	264.0	41.0
	Møbler og elektro	Furniture and electronics	37.0	8.0
	Jernvare/Fargevare og annen byggvare	Hardware/paint, etc.	37.0	5.0
56	Barer	Bars	8.0	2.0
	Restauranter	Restaurants	138.0	12.0
96	Personlig tjenesteyting	Personal services	32.0	21.0

Figure 1.26– Businesses in Hillevåg (source: SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

This shopping mall is one option visitors have should they decide to avoid driving in the city center. Given its location on the outskirts of the city center, there is immediately more open space, but the area lacks an urban feel as seen in *figures 1.27 – 1.29*.

Image capture: Oct 2020 © 2021 Google

Figure 1.27–View of Kilden Mall and open space (source: maps.google.com)

Image capture: Oct 2020 © 2021 Google

Figure 1.28–View of Kilden Mall and its parking structure (source: maps.google.com)

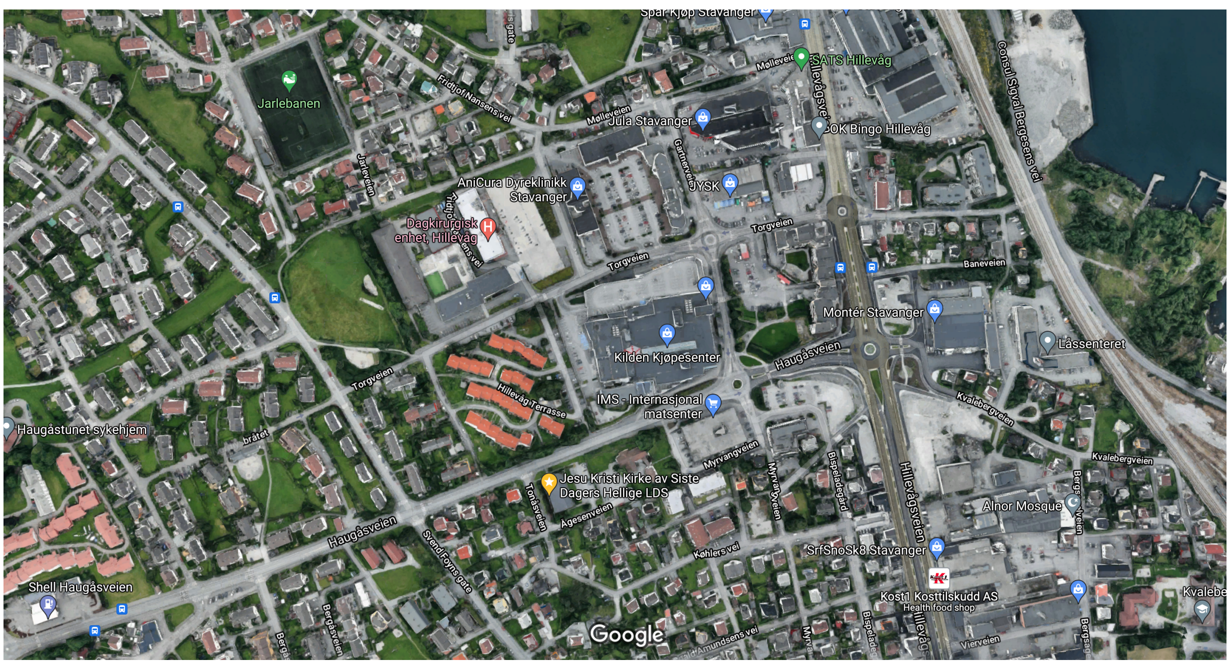


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Figure 1.29–Satellite view of Kilden and its surroundings in Hillevåg (source: maps.google.com)

Amfi Madla is a mall located about 4 kilometers west of the city center. This is a stop-and-shop location with 80 stores covering 69.000 square meters and is Stavanger municipality's largest mall (Amfi Madla, 2021). The number of businesses in the postal code of 4042 (see *figure 1.14* to see where) is shown in *figure 1.30*. The suburban setting of Amfi Madla is clearly visible from the *figures 1.31-1.33*.

Employees and businesses in post number 4042 (Madla)

Ansatte og virksomheter - Velg postsone(r) i kartet

Hovedgrup..	Gruppering		Number of employees Antall ansatte	Number of businesses Antall virksomheter -
47	Dagligvare	Groceries	214.0	7.0
	Klær, sko og vesker	Clothes, shoes, purses	125.0	20.0
	Sport, spill, leker og bøker	Sports, games, toys, books	48.0	7.0
	Annen utvalgsvare	Other	303.0	27.0
	Møbler og elektro	Furniture and electronics	25.0	4.0
	Jernvare/Fargevare og annen byggvare	Hardware/paint, etc.	0.0	1.0
56	Restauranter	Restaurants	82.0	10.0
96	Personlig tjenesteyting	Personal services	65.0	13.0

Figure 1.30– Businesses in Madla(source: SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

Figure 1.31–View of Amfi Madla and gas station from Revheimsveien (source: maps.google.com)

Image capture: Jun 2019 © 2021 Google

Figure 1.32–View of Madlakrossen and Amfi Madla (source: maps.google.com)

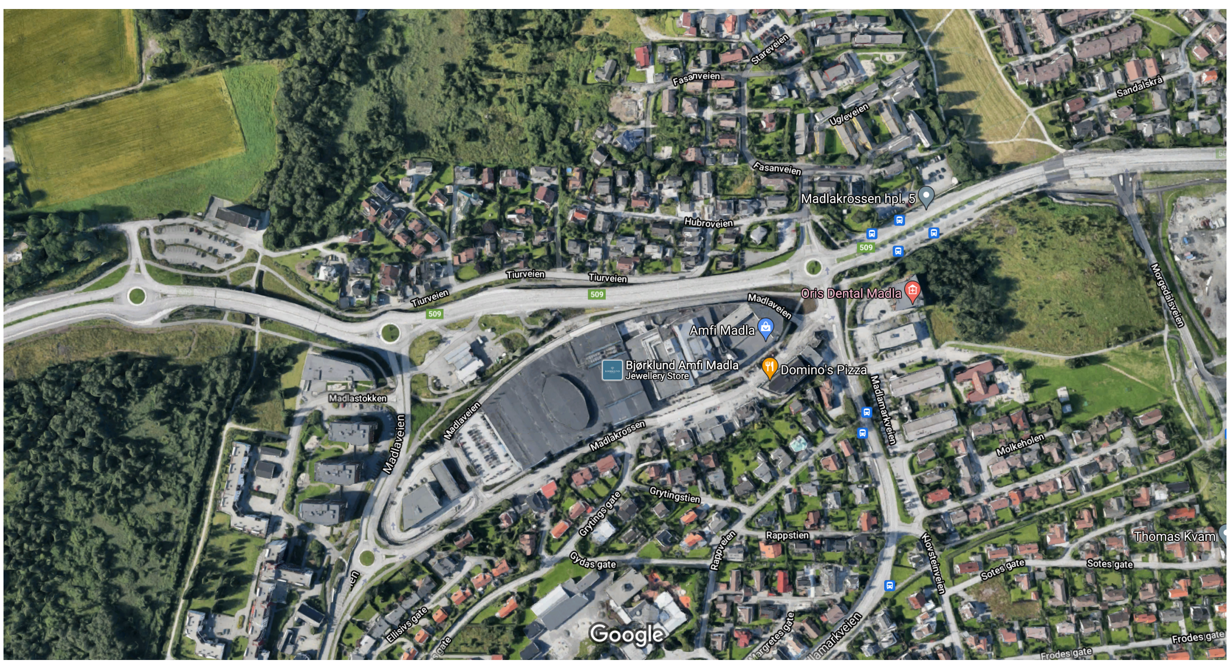

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Figure 1.33–Satellite view of Amfi Madla and its low-density surroundings (source: maps.google.com)

1.2 Thesis Questions

The thesis questions were developed in collaboration with Stavanger Municipality and came as a result of a series of formal and informal discussions with stakeholders. The thesis question is stated as follows:

How will the new municipal sub-plan impact travel time and car accessibility for visitors driving to Stavanger City Center? And how will it affect the competitiveness of the city center?

The goal of this thesis is to shed light on the impact that the plans outlined in the municipal sub-plan can have on travel time for those who drive to the city center, and attempt to discuss some of the implications that this impact can have on accessibility and competitiveness of the city center.

2. LITERATURE REVIEW

The literature covered in this chapter was selected to create a theoretic foundation and a framework of definitions for the analysis and discussion.

2.1 Travel time, Accessibility and Mobility

As a concept in transportation, accessibility could perhaps be the core concept given that the purpose of most travel is to interact with the opportunities at a destination. Opposite from mobility which is the ease of moving along a network, transportation and urban planning literature commonly define accessibility as the ease of reaching destinations or activities (Venter, 2016).

Figure 2.1 shows traffic-, mobility-, and accessibility view as connected concepts with different concerns and actions. Accessibility view concerns itself with travel time to reach a destination. What separates the other views from accessibility view is the focus on destination. Without the destination as a part of the concern it becomes a different view.

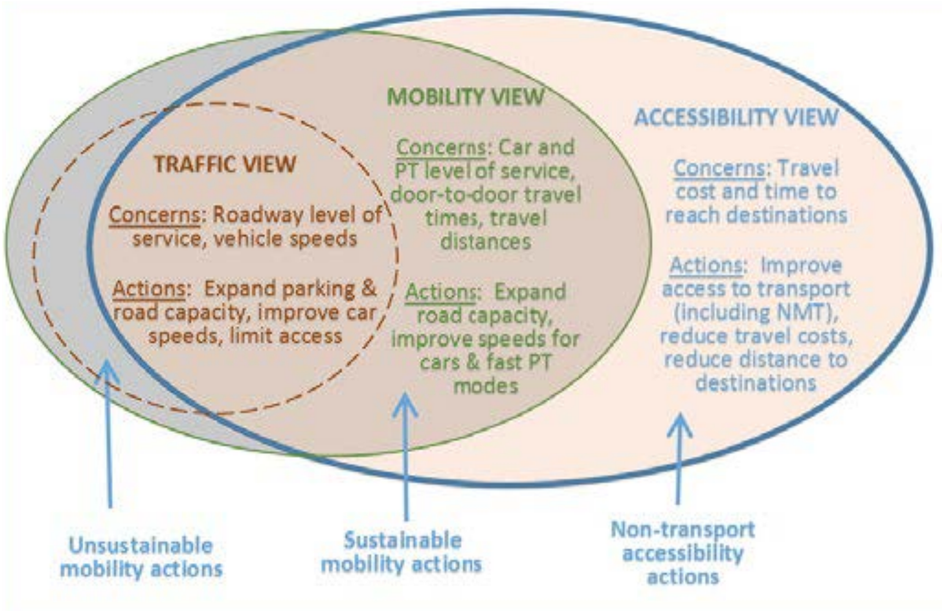


Figure 2.1–Different views on mobility concepts (Venter, 2016)

A traffic-based view of urban transportation, focusing on increasing capacity and expanding parking, is a view that is very much challenged today as it mostly considers the motorists while ignoring other transport users (Venter, 2016). The concept of mobility gives a broader perspective than a traffic-based view by recognizing the reliance on other modes of transportation than driving such as walking, biking and public transit (Venter, 2016). An accessibility-based approach in many cases focuses on shortening travel distances and promotes walking instead of driving, but it also values each transportation mode's contribution to meeting the user's transportation needs (Venter, 2016).

While mobility plays an important part in providing accessibility, it is only a means to an end. Both mobility- and accessibility views concern themselves with travel time; however, only accessibility concerns itself with what's at the origin and destination (Venter, 2016).

When it comes to travel behavior and route preferences, although it is not the only factor affecting route-choice behavior, travel time does seem to be the main variable differentiating a driver's route choice (Harder, Bloomfield, Levinson, & Zhang, 2005).

A model used in the theory of the value of travel time is the activity-based model (Swärdh, 2009). This model is built on the basis that people travel in order to take part in activities that increase utility (Swärdh, 2009), and it support the claim that mobility, which is mainly focused on the movement along a network, is a means to an end. And if traveling is treated as a service and not a source of utility, individuals might be willing to pay to reduce it (Swärdh, 2009).

A paper by (Geurs & Wee, 2004) offers an influential review of the components of accessibility. The components are land-use, transportation, temporal, and individual. These components serve an important role in attempting to measure accessibility, and are as follows:

- The land-use component is a three-part component and consists of 1) "the amount, quality and spatial distribution opportunities supplied at each destination," 2) "the demand for these opportunities at origin locations," and 3) "the confrontation of supply of and demand for opportunities" (competition). (Geurs & Wee, 2004).

- The transportation component consists of travel time, costs, effort, and supply and demand of infrastructure.

- The temporal component has to do with the time restraint when it comes to the availability of opportunities.

- The individual component takes into consideration the demographics, abilities, and opportunities of the individual.

When it comes measuring accessibility in a transportation context, Geurs and Van Wee acknowledge that due to its complex definition and number of components, it is impractical to have a single indicator. And measures often used (termed infrastructure-based measures by (Geurs & Wee, 2004)) such as network connectivity, travel time, speed, level of service, and congestion completely ignore the land use component of accessibility (Venter, 2016).
The term accessibility appears to be used as a measure of the quality of three things: mobility, access to transport, and access to opportunity. (Venter, 2016)

When it comes to an indicator for the measure of accessibility (Venter, 2016) points out that the most popular one used in descriptive studies appear to be cumulative contour measures together with gravity-type measures (Venter, 2016). Gravity-type measures reflect the decreasing attractiveness of locations far away by making the opportunities at the destination a function of travel time (Venter, 2016). (Bhat, et al., 2001) adds that the value of cumulative opportunities measures is the sum of opportunities within a distance or travel time (Bhat, et al., 2001).

Interestingly, (Venter, 2016) points out that "trip distances tend to increase with increasing accessibility... Thus, overall vehicle miles traveled strongly increase with regional accessibility" (Venter, 2016). This helps understand the role that cars play in providing a form of accessibility for people living outside the urban areas of Stavanger. On the other side of that, with an increased interest in transit-oriented development and the effort to promote co-location of jobs and housing, (Venter, 2016) also points out that "over time this effect might be weakened, due to co-location of jobs and housing to keep average travel times constant" (Venter, 2016).

When it comes to accessibility and car ownership, (Venter, 2016) points out that "while greater neighborhood accessibility is associated with reduced car ownership due to the proximity to more opportunities within walking distance, regional car accessibility has been found to be positively correlated with car ownership" (Venter, 2016). This helps shed light on the potential relationship between the 46 percent of trips that are made to the city center by car, and the regional car accessibility in the Stavanger region.

2.2 Critical Distances

Even though the focus of this thesis is on car accessibility and not pedestrian accessibility, critical distances for walking can help put the analysis into pedestrian scale, contextual perspective and add a level of analysis to the thesis.

Guidelines in service planning from Sydney to Vancouver frequently use a walking distance of a quarter-mile (400 meters) as a general rule in planning distance to bus lines for example; however, the origin of these key distances are somewhat unclear (Daniels & Mulley, 2011). Similarly, U.S. research studies have also deemed a distance of 0.25 miles, or 400 meters, as an acceptable walking distance (Yang & Roux, 2012). It is important to take into consideration that these key distances are with a specific purpose in mind, such as distance to public transportation. Even then, people tend to be willing to walk further to ride the train than to ride the bus (Daniels & Mulley, 2011). In a national travel survey for Norway (Denstadli & Hjorthol, 2003) it was pointed out that at distances nearing 1000 meters, more individuals tend to choose to drive than walk (Denstadli & Hjorthol, 2003).

When it comes to critical travel times, concepts like the “10-minute city”, the “15-minute city”, or even the “20-minute city” are urban models popularly discussed to address urban challenges. Behind what seems like ambiguous time limits is the principle of cities with reasonable proximities, having essential services within a certain close-proximity walking- or biking distance.

“The 15-Minute City rides on the concept of ‘chrono-urbanism’, which outlines that the quality of urban life is inversely proportional to the amount of time invested in transportation, more so through the use of automobiles” (Moreno, Allam, Chabaud, Gall, & Pratlong, 2021).

Although one of the major selling-points of this concept is car-free cities, the principle of reasonable proximities can still be applied to regional car accessibility as a form of temporal framework.

2.3 City Centers and Competitiveness

This topic is relevant in order to understand the intra-urban relationship the city center of Stavanger theoretically has with other retail agglomerations in the Stavanger region.

Studies from the last decade have revealed that the intraurban central hierarchical structure has remained robust, opposite from what many geographers expected, and historic city centers in European cities “remain at the top of the retail hierarchy” (Hatz, 2006). (Hatz, 2006) also points out that “these findings are supported by concepts based on central place theory, evolutionary economics and the new retail geography” (Hatz, 2006). The findings that the hierarchical structure has remained strong mean that the fundamental advantage the city center of Stavanger has due to its hierarchical status still exists. (Hatz, 2006) also mentions that “in terms of changing shopping attitudes of a post modern society as well as the growing competition between cities, the consumption of the city centre with its unique atmosphere becomes part of consumption itself” (Hatz, 2006). The city center has so much more than what a mall in the “suburbs” has to offer because of the regional hierarchy, specialization, sense of place, and variety of services, bars, cafes, and restaurants. Along with that (Hatz, 2006) explains that the competitive advantage of a city center comes from its vitality, that being both the number and variety of shops (Hatz, 2006).

2.4 Conclusions from Literature Review

Take-aways from literature review on **travel time, accessibility** & **mobility**:

- Although it plays an important role in providing accessibility, mobility is a means to an end, and different from accessibility because it lacks the land-use component.
- Travel time is a key part of the transportation component of accessibility.
- Travel time is the main variable in differentiating between route-choice behavior (Harder, Bloomfield, Levinson, & Zhang, 2005).
- An accessibility indicator is the sum of opportunities within a distance or travel time, often shown spatially by a combination of a contour and gravity-type measure and involves multiple factors.
- "Overall vehicle miles traveled strongly increase with regional accessibility" (Venter, 2016)

Take-aways from literature review on **critical distances:**

- When it comes to discussing proximity to the city center and destinations, the **400-meter** distance can be used as an acceptable threshold in discussion with regards to the perspective involving public transit, and the **1000-meter** distance can be used in discussing the likelihood of someone choosing to drive or not.
- 15 minutes of travel time will be used as a reasonable temporal framework in the analysis.

Take-aways from literature review on **city centers & competitiveness:**

- The intraurban hierarchical structure remains strong (Hatz, 2006).

- The urban atmosphere of city centers becomes part of the consumption and is bigger than shopping alone (Hatz, 2006).
- Vitality = number and variety of shops (Hatz, 2006)
- Vitality is what gives the city center its competitive advantage (Hatz, 2006)

3. METHODOLOGY

This thesis is an exploratory ex-ante impact assessment that uses *GIS service area analysis* to model changes in travel time represented by network service area following the implementation of projects in the municipal sub-plan. The thesis explores implications from a change in travel time on car accessibility and competitiveness of the city center.

3.1 Approach: GIS Service Area Analysis

A network service area is found using Network Analyst in ArcGIS Desktop which allows you to find areas surrounding one or multiple facilities (locations) in a network (see *figure 3.1*).

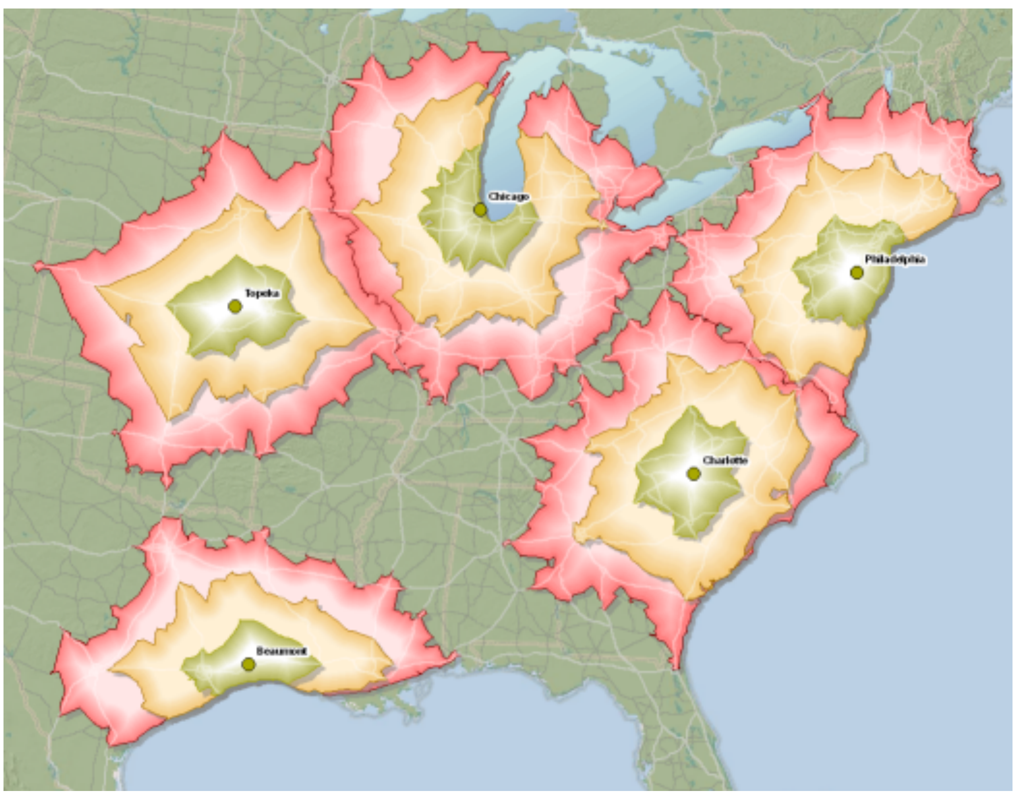


Figure 3.1–Multiple-facilities service area analysis (source: https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/service-area.htm)

A service area is the area reachable on a network within an impedance (see *figure 3.2*). The impedance for this analysis is travel time in minutes. E.g., a 15-minute impedance for a service area shows an area in which the destination (facility) can be reached within 15 minutes.

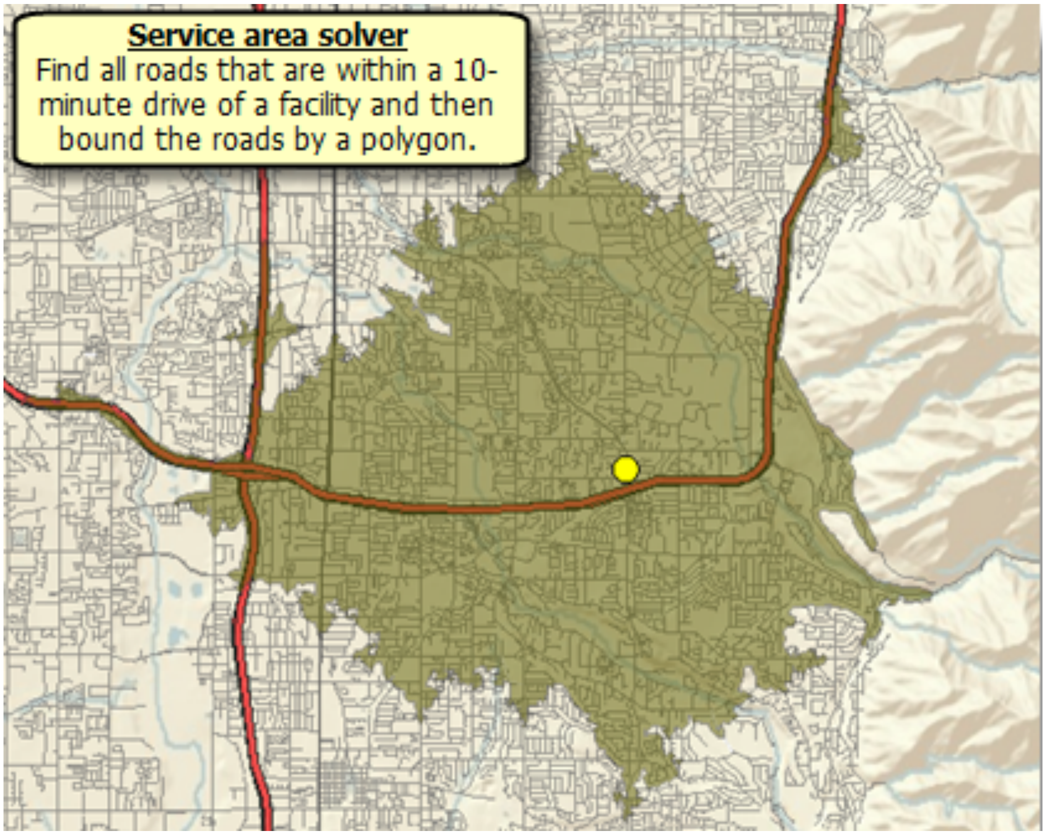


Figure 3.2–10-minute service area (source: https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/service-area.htm)

The service area can have one or multiple service polygons with different impedance breaks (e.g. 5 minutes, 10 minutes, 15 minutes) This creates a contour effect that shows travel time spatially as shown in *figure 3.3*.

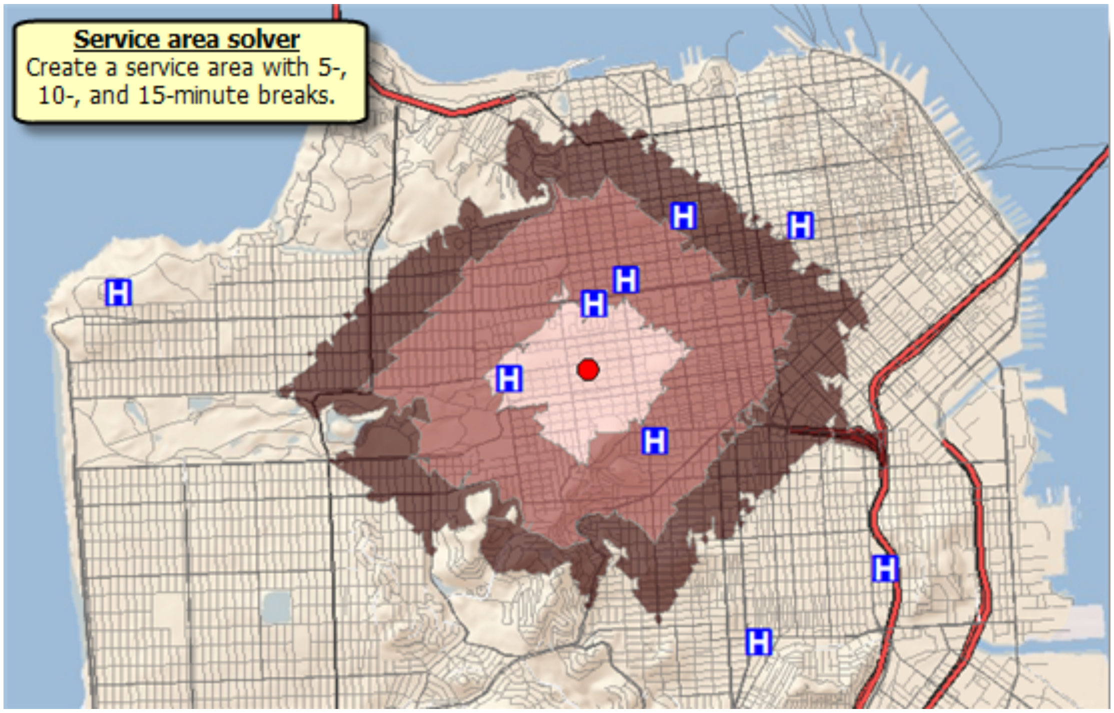


Figure 3.3–Service area with multiple impedance breaks (source: https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/service-area.htm)

The reasons for choosing a technical GIS analysis approach have to do with the nature of the task. The primary thesis question (*how will the new municipal sub-plan impact travel time and car accessibility for visitors driving to Stavanger City Center?*) concerns itself with travel time as an important component of accessibility and will be answered by modeling the travel time using GIS *service area analysis* on the current road network, and by comparing it to travel time on the new road network. This comparison will show the impact the municipal sub-plan will have on the *transportation component* of accessibility in Stavanger.

The secondary thesis question (*how will it affect the competitiveness of the city center?)* is more exploratory and will be best answered by building on the service area results and by placing these results within the local context and physical planning perspective. As discussed in the literature review (chapter 2), the most popular indicator of accessibility was a combination of cumulative contour and gravity-type measures; however, only the travel time component of accessibility will be measured using GIS analysis. The question of how the change in travel time affects competitiveness will be answered by comparing service areas with Madla and Kilden in relation to each other, in that same local context and physical planning perspective. In the context of competitiveness, the term "catchment area" will be used instead of service area in order to give it applied meaning for the sake of the analysis.

GIS is a technical tool that can efficiently organize and display large amounts of spatial information. GIS allows for editing data and spatial attributes which was crucial because the current roads data only shows the way things are today, and this data manipulation allowed the modeling of future travel times. Given that this is a local network problem with regional repercussions, using GIS network analyst allowed for a large geographical network area to be analyzed.

Some challenges with using ArcGIS Desktop (also referred to as ArcMap) is the relatively frequent temperamental freezes and shutdowns. As with most things, this requires frequent saving and patience on many levels. The ArcGIS software available for this thesis (ArcGIS Desktop) was somewhat dated, and access to ArcGIS Pro would have been preferred because of the more project-centric approach and live editing compatibility that is lacking with ArcGIS Desktop. Another challenge with using GIS software in general is the large amount of technical computer software configurations that require intense focus, attention to detail and a moderate knowledge of computer science in general. A significant amount of time is often spent troubleshooting and problem-solving before successfully running analysis tasks, and the process can be very time-consuming.

Drawbacks with using this type of technical analysis is that the analysis tools only process the data you feed it. A technical analysis alone does not take into consideration the human behavior aspect, and travel time models may look more dramatic than they are. Therefore, it is important to discuss the results and implications in a human context. This is done in this thesis by adding layers of analysis to the technical maps and discussing the observations in a local perspective.

Alternatives network analyses to *service area analysis* are ‘closest facility’, ‘OD cost matrix’ measuring least-cost paths, ‘vehicle routing problem’, or ‘location-allocation’. Combined, these could produce valuable analytical results; however, *service area analysis* was one that could spatially show travel time for the entire region all at once. Other alternatives to a GIS service area analysis could be a non-technical analysis focusing on qualitative attributes of the road network before and after project implementation. A non-technical qualitative analysis would most likely need to be in a large-scale format, and it would be difficult to model the travel time impact 15 to 20 minutes away from the city center. Although this thesis is about local plans and road network changes in the city center, the impact and implications reach far outside the city limits.

3.2 Data & Configurations

In order to perform the GIS analysis, it was necessary to set up a geodatabase in ArcGIS Desktop. A geodatabase is a database used to store datasets, manipulate and query spatial or geographical information. It is also the data format used in managing and editing geographic data in ArcGIS.

A data set called "NVDB Ruteplan" from Statens Vegvesen contained a road network layer comprising secondary data and was downloaded via Geonorge (Statens Vegvesen, 2021). This roads layer (in reference system EUREF89 UTM sone 33, 2d) contains an attribute table with each road segment and included accompanying information like travel time, distance, road direction, etc. The data set was exported to the project geodatabase where the roads layer with all its accompanying data was duplicated. The original roads layer was used in modeling current service areas (travel time), while the duplicate layer was manually edited to reflect the future changes to the roads network and the consequences for cars (*figure 1.12*), in order to model the service area on the network proposed in the municipal plan.

The roads layer edits were based on the consequences for cars (*figure 1.12*) which were based on the proposed projects (*figure 1.11*), and made in collaboration with Stavanger Municipality. As the implementation of the 2019 municipal sub-plan is an ongoing endeavor, the consequence map for cars is as current as the projects approved by the municipal committees as of February 2021.

Due to the nature of the municipal implementation process, the projects and order of implementation are subject to change, which would affect the consequences and final analysis maps. The procedure of the analysis in this thesis, however, remains the same and is replicable.

In order to run the network analysis, the data needed to be in a network database. A network database contains lines of network flow along with other attributes necessary to perform the analysis. After the network database was created (one for the original road network, and one for the edited roads layer), the service area task was set up using the network analyst. The service area task input was the roads layers (lines), and the facility/facilities (points). The facility location in the city center was set up to be Arkaden Parking (*figure 1.16*).

After the task was executed, it remained to configure layer properties and symbology settings. The analysis task was manually configured to calculate the service area based on travel time towards the facility, as opposed to going "away from" the facility. This was an important detail because the purpose of the analysis is to assess travel time to the city center, and a small detail like that can cause inaccuracies along highways and areas where there's a considerable distance between exits and intersections because direction matters. In the multiple facilities analysis, the configuration was set to allow for no overlap in between the service areas giving each area a clear boundary of nearest facility.

The analysis maps were made to show 10-, 15- and 20-minute service areas. 10-minute service area is only used to show local detail and the amount of change in travel time and area. The 1-minute travel-time polygons add a level of detail which can give an indication of how much the travel time changes when comparing the current and new service areas.

The 15-minute service area covers the four city zones of urbanity (see *figure 1.9*) and is a useful perspective when looking at the implications for the development- and transit corridors, and beyond. It is also a temporal framework of reasonable travel time as discussed in the literature with regards to 15-minute cities and the concept of "reasonable proximity". The 20-

minute service area is a small-scale regional view that is valuable when looking at impact in the Stavanger/Sandnes metropolitan area with 5-minute impedance breaks intended to minimize distractions of too much detail, and mostly focus on the change in 20-minute service area with regards to its connection with Sandnes.

For the multi-facility analysis used to analyze the changes in catchment areas (section 4.2), Madla, and Kilden were included so there were three facilities in total. The facilities were connected to the road network and were placed right at the entrance to respective parking structures for accuracy in the travel time calculations. The nearest facilities (in travel time) are then represented by their respective catchment areas. The catchment area was set to 15-minutes; however, with the no-overlap setting and three facilities (Arkaden, Madla, and Kilden), the catchment areas meet and it becomes a nearest-facility task where the borders meet.

4. ANALYSIS

Presented in this chapter are the results from the *Network Service Area* analysis along with an analysis of these results in a local context.

4.1 Service Area & Travel Time

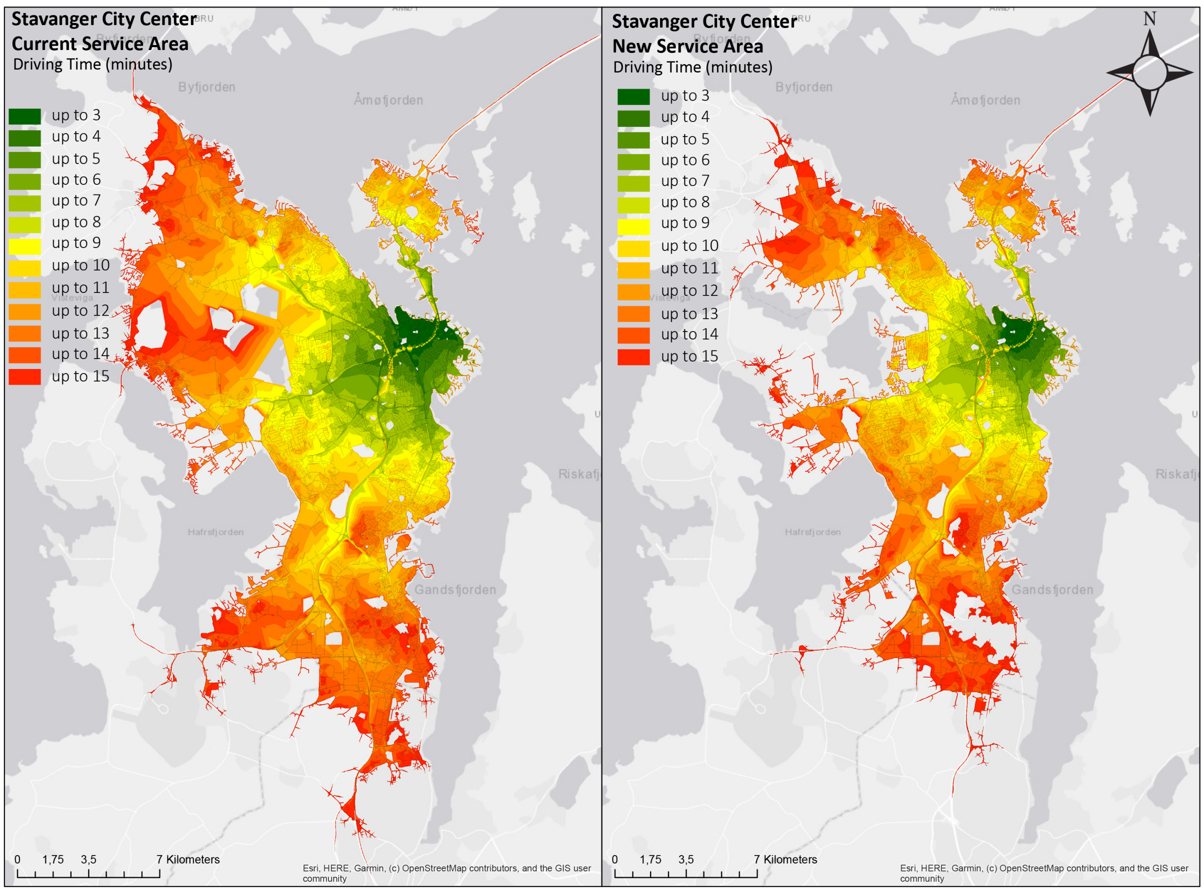


Figure 4.1–15-minute service area before and after with 1-minute impedance breaks (own figure, data collected from Statens Vegvesen)

In *figure 4.1* the side-by-side view of the Stavanger City Center service area offers a view into how it is currently, (on the left) and what it will be after the projects are implemented, (on the right). The impact found by comparing the current and the new service areas is noticeable several places where the travel time polygons change their shape and thus the location changes color. The shrinking of a travel time polygon means that there is a change in travel time because that same location is no longer reached with the same time impedance. All new service area polygons are smaller, placing any same location in a higher travel time polygon which is also evidence that the travel time increases.

The new 15-minute service area is smaller than the current one, and several locations that currently find themselves within a reasonable 15-minute drive of the city center fall outside this limit in the new service area.

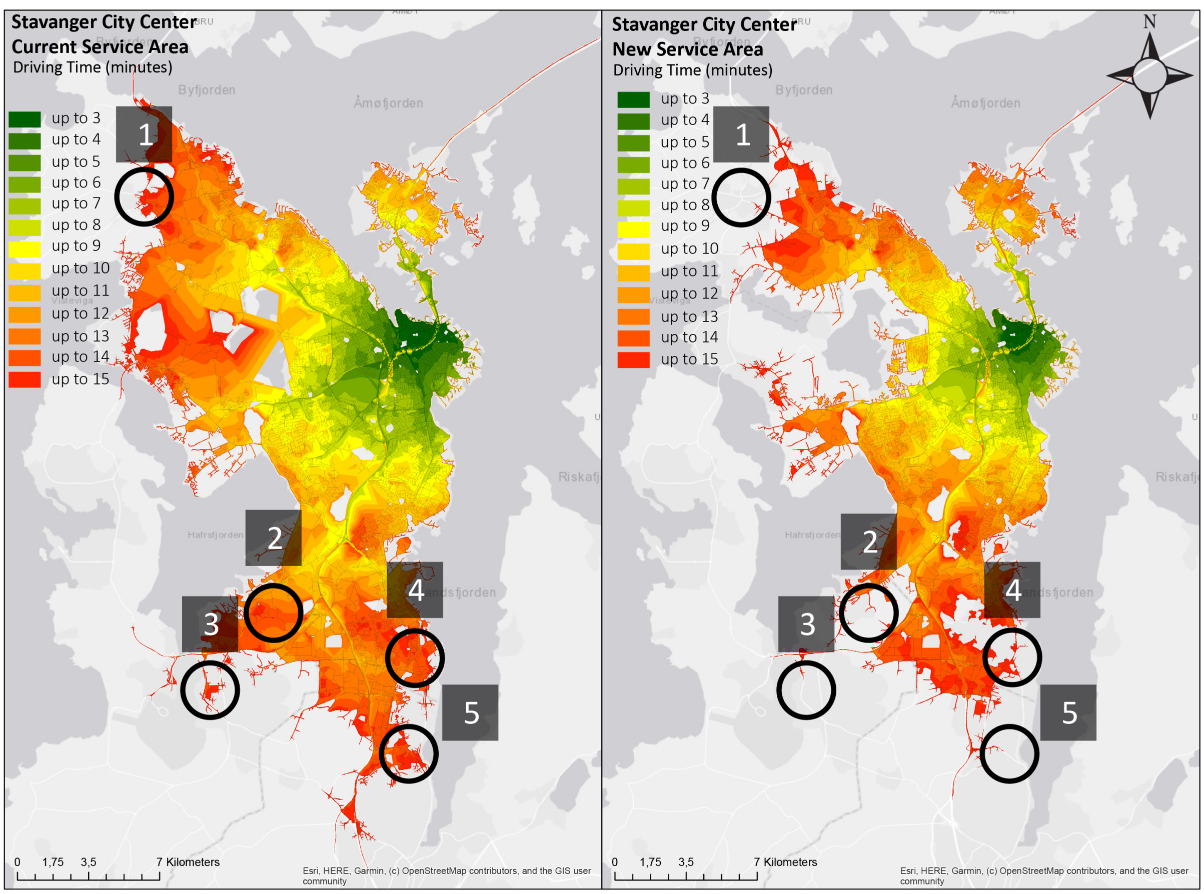
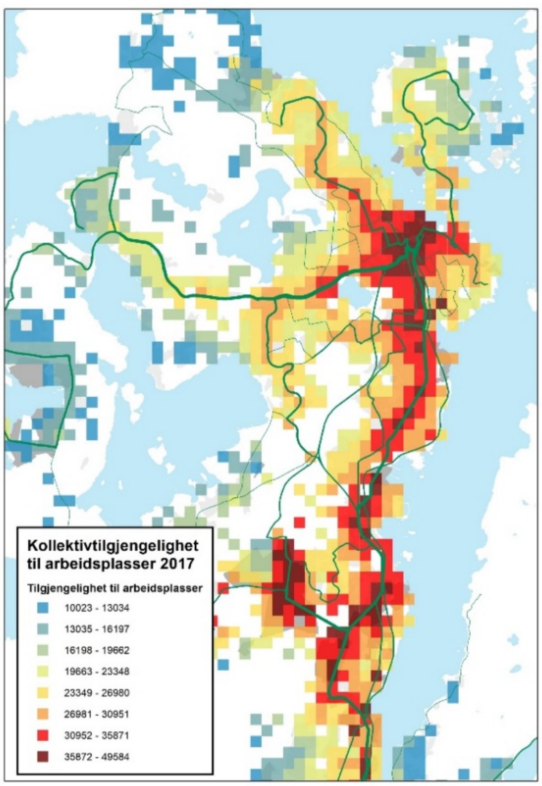


Figure 4.2–15-minute service area before and after with 1-minute impedance breaks and locations (own figure, data collected from Statens Vegvesen)

Figure 4.2 marks five spots that fall outside the 15-minute drive from the city center with the new service area. These areas include Randaberg (1), Sørnes (2), Solakrossen (3), Forus (4), and Lura (5). Forus (4) is the only district in Stavanger municipality; however, all these areas could arguably be considered to be in the cultural and economic catchment area of the regionally significant Stavanger City Center. When looking at *figure 4.4* it appears that these areas (1-5) have a higher share of car-ownership, and at least Randaberg (1) and Sørnes (2) seem to be located outside the public transit access corridor (see *figure 4.3*) with a higher proportion car ownership than the areas in the city development zones A & B (see *figure 1.9*).



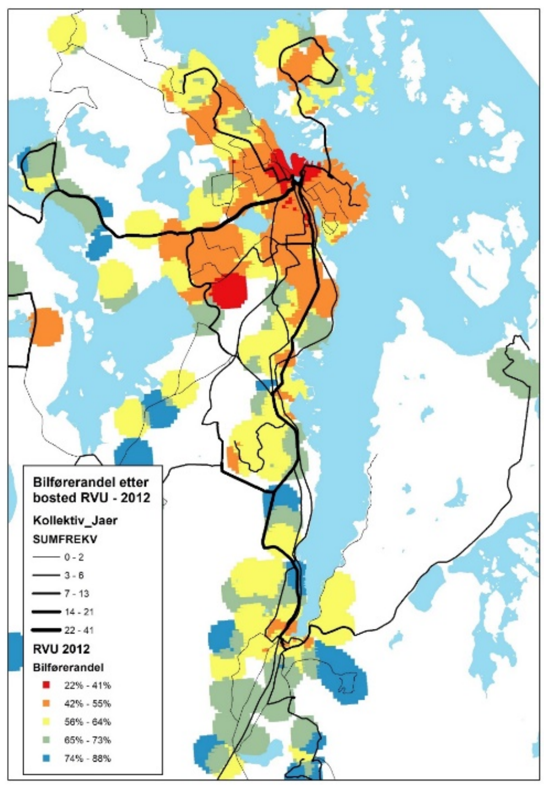


Figure 4.3–Accessibility to jobs via public transit (Stavanger Kommune, 2019)

Figure 4.4–Car ownership (Stavanger Kommune, 2019)

Figure 4.5 shows the diminished reach of the 20-minute drive, in particular east of the Sandnes City Center in the south of the map view.

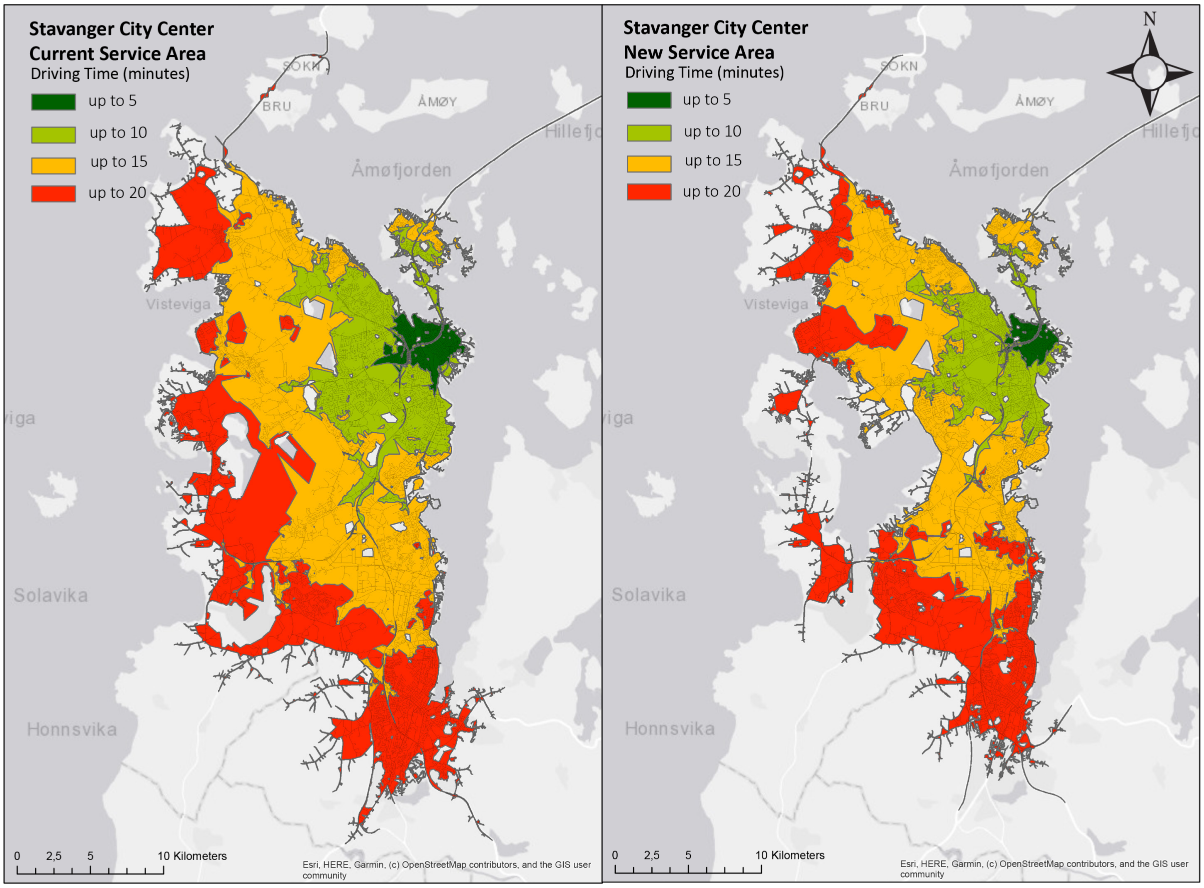


Figure 4.5–20-minute service area before and after with 5-minute impedance breaks (own figure, data collected from Statens Vegvesen)

The travel-time seems to increase between one and two minutes. The travel-time change has a ripple effect that reaches the edge of the 15-minute service area. The areas with the highest travel time increase seem to be located north, west and south of the city center.

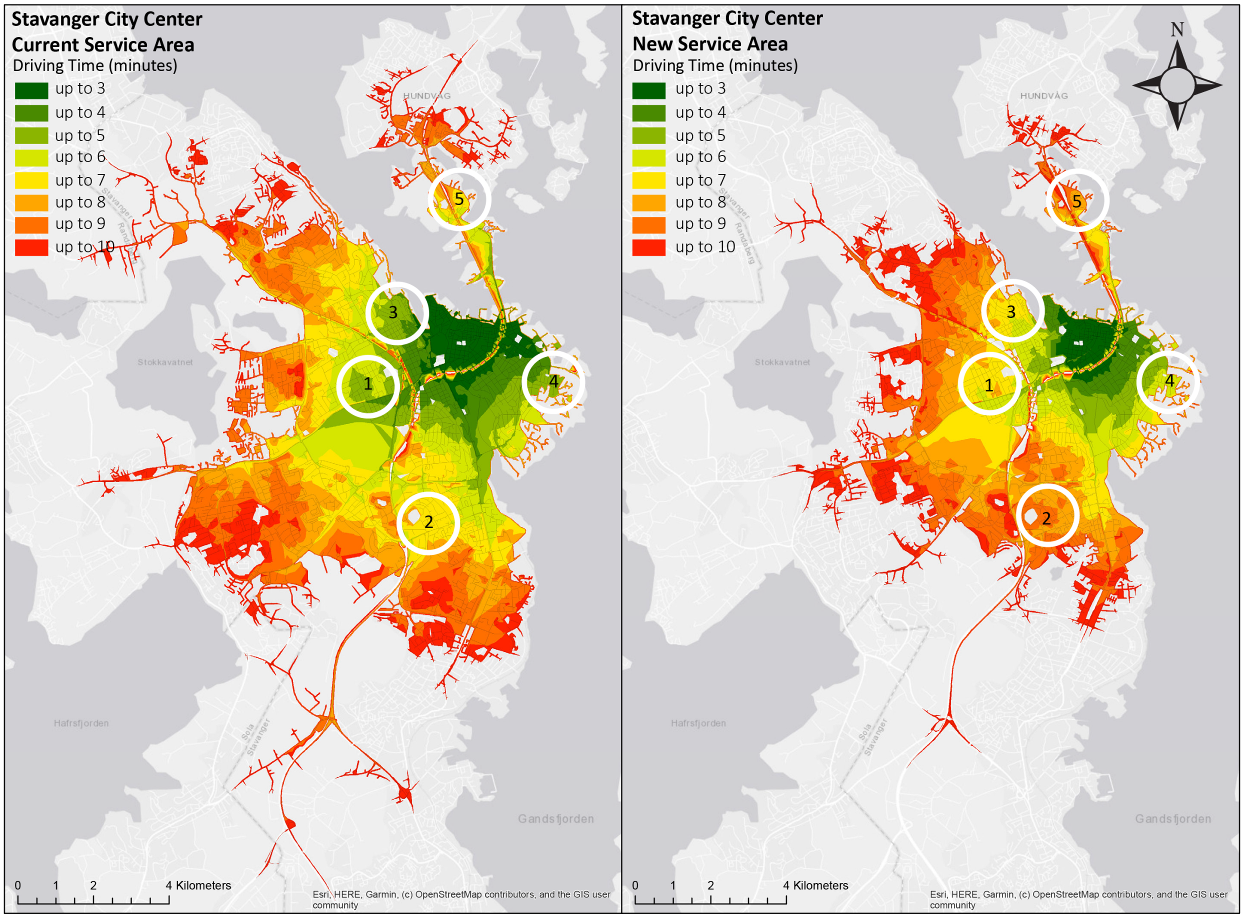


Figure 4.6–10-minute service area with 1-minute impedance breaks and locations (own figure, data collected from Statens Vegvesen)

As seen in *figure 4.6*, points 1-3 increase two one-minute-categories while points 4 and 5 only go up one. Locations west and south of the city center show a travel-time increase of about two minutes, while areas east of the city center including Hundvåg seem to only see a one-minute increase. On a 10-minute drive that equals up to a 20 percent travel time increase. As demonstrated in the introduction, travel routes from the north, west and south experience longer detours due to the road network changes, than trips originating in the east at Hundvåg and Storhaug.

At a larger scale in Stavanger, the biggest service area loss within 10-minutes of the city center seems to be north, west and south of the city center (see *figure 4.7*). These are also the areas with the biggest travel time increase. The visible arteries that stretch south like fingers on a hand form along roads with higher speeds e.g. freeways due to the higher speed limit which increases the movement along the network, increasing the mobility. These arteries also naturally shrink in the new service area.

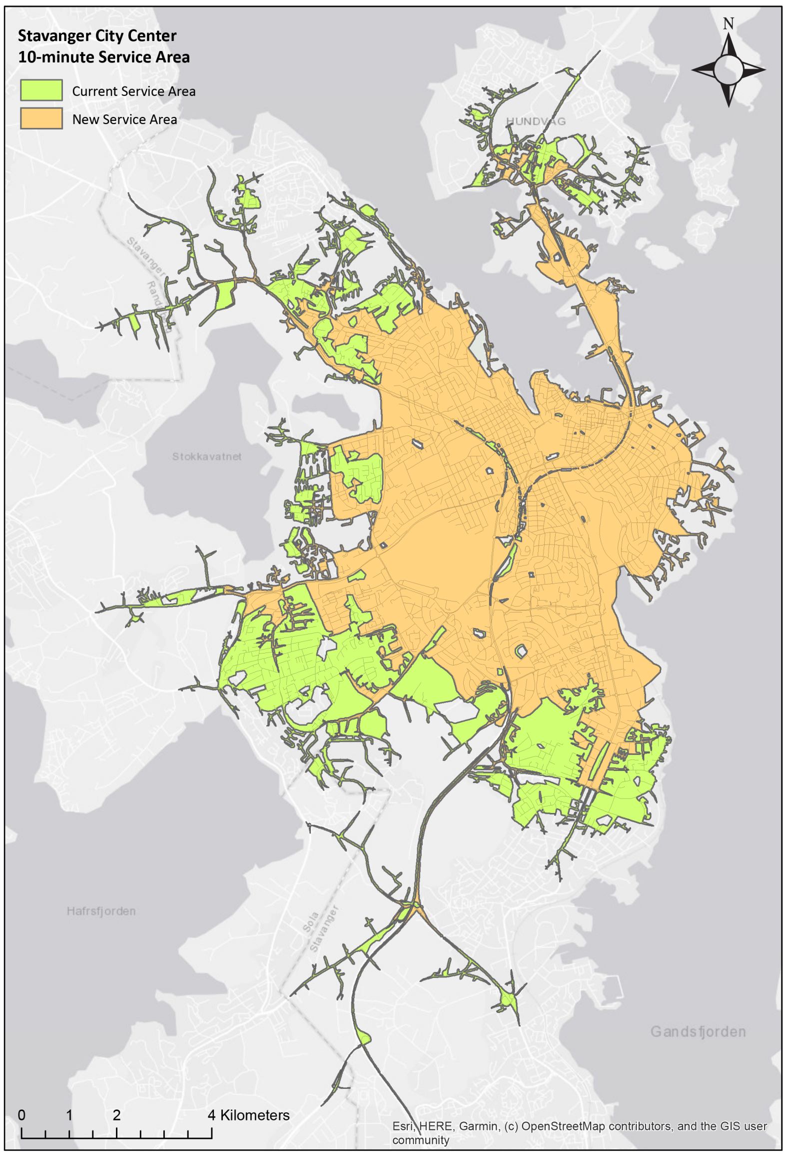


Figure 4.7–10-minute service area before and after (own figure, data collected from Statens Vegvesen)

4.2 Catchment Area & Competitiveness

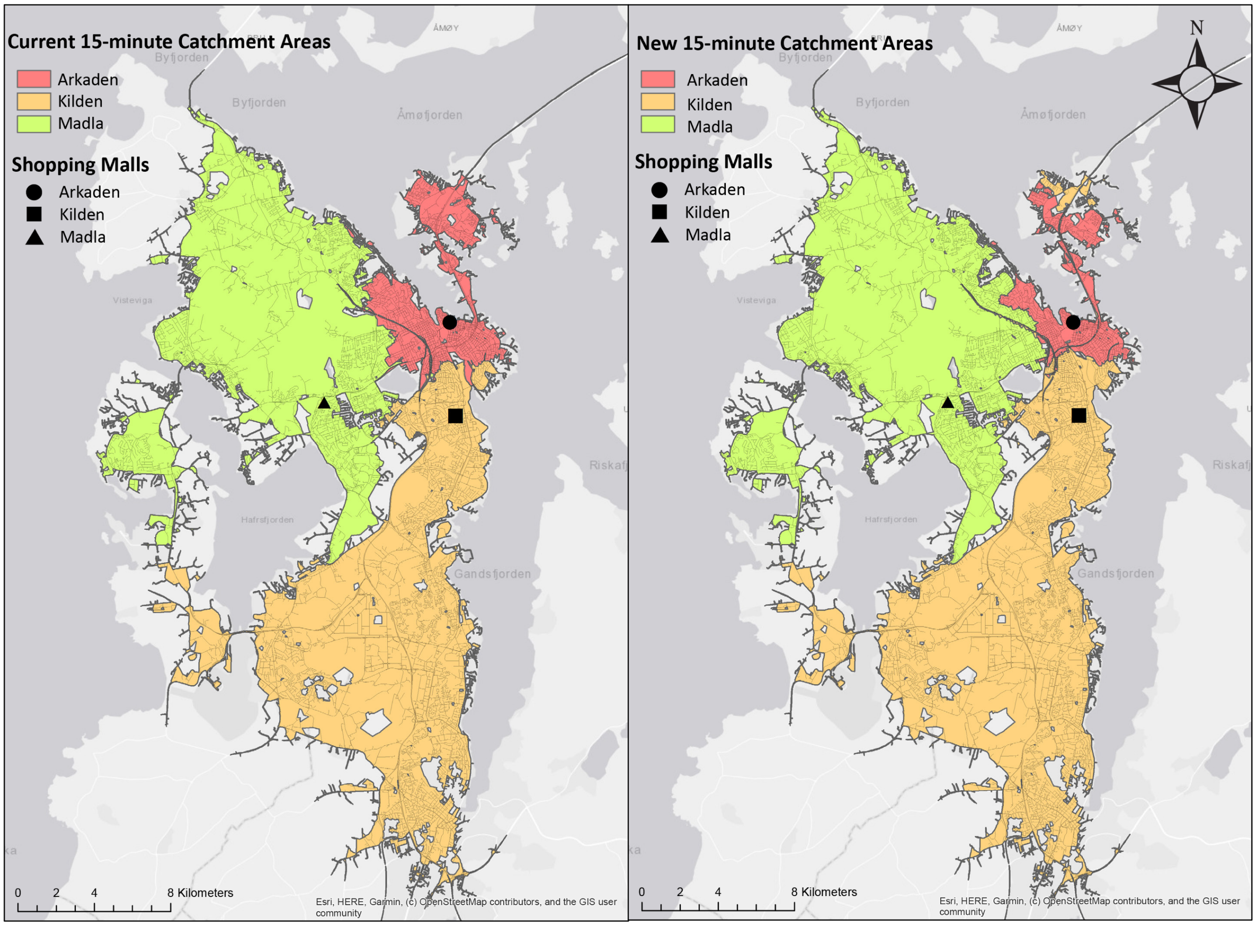


Figure 4.8–15-minute catchment areas before and after (own figure, data collected from Statens Vegvesen)

Figure 4.8 shows how 15-minute catchment areas for Arkaden, Kilden and Madla change in relation to each other before and after the implementation of the municipal plan. The analysis reveals that Stavanger loses service area to Madla and Kilden with the new road network (see *figure 4.9*). Hundvåg, whose nearest mall on the current road network is Arkaden, splits and the northern half becomes part of Kilden's catchment area. A reason for this is that the changes to the road network add enough time to the trip to where the trip through the Ryfast/Hundvåg tunnel over to Kilden becomes faster than navigating the new travel route in the city center to Arkaden Parking.

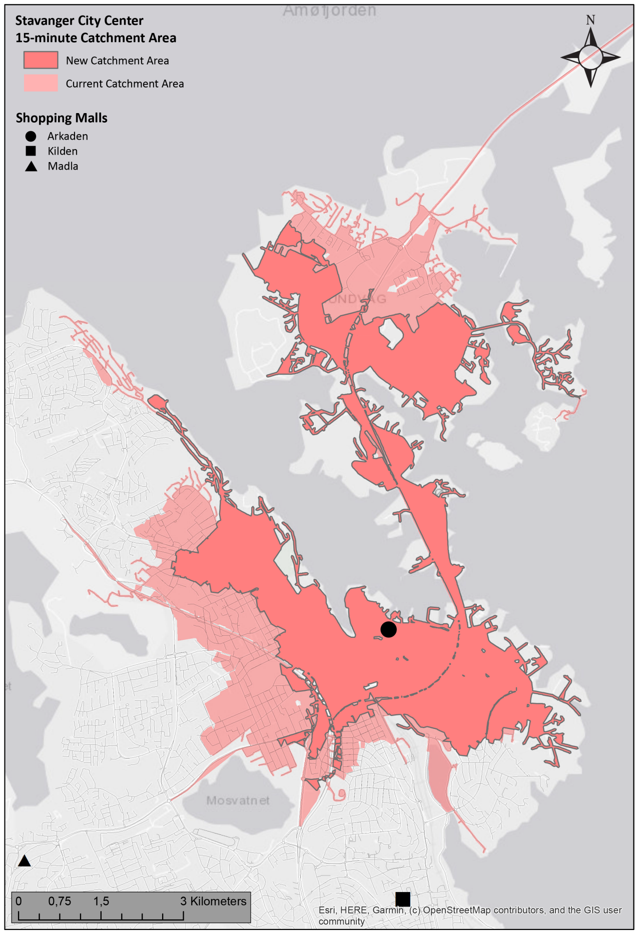


Figure 4.9–City center catchment area before and after (own figure, data collected from Statens Vegvesen)

Figure 4.9 provides a good view of in what is happening to the Stavanger City Center catchment area and straightforwardly shows the area that is lost due to the increased travel time to Arkaden Parking. Other than the previously discussed Hundvåg area being lost to Kilden, a part of Eiganes which on today's road network is closest to Arkaden in the city center, will on the new road network be closest to Madla. Although they might be closer to Arkaden in actual distance, their closest facility (shopping mall) by car becomes Madla because of the detours on the new road network. This affects the people that depend on a vehicle whether for convenience, comfort, or safety. The toll road barrier created around the city center (see *figure*

4.10) might play a bigger part in people's route-choice behavior if they in addition to having to pay a toll have two extra minutes added to their trip.

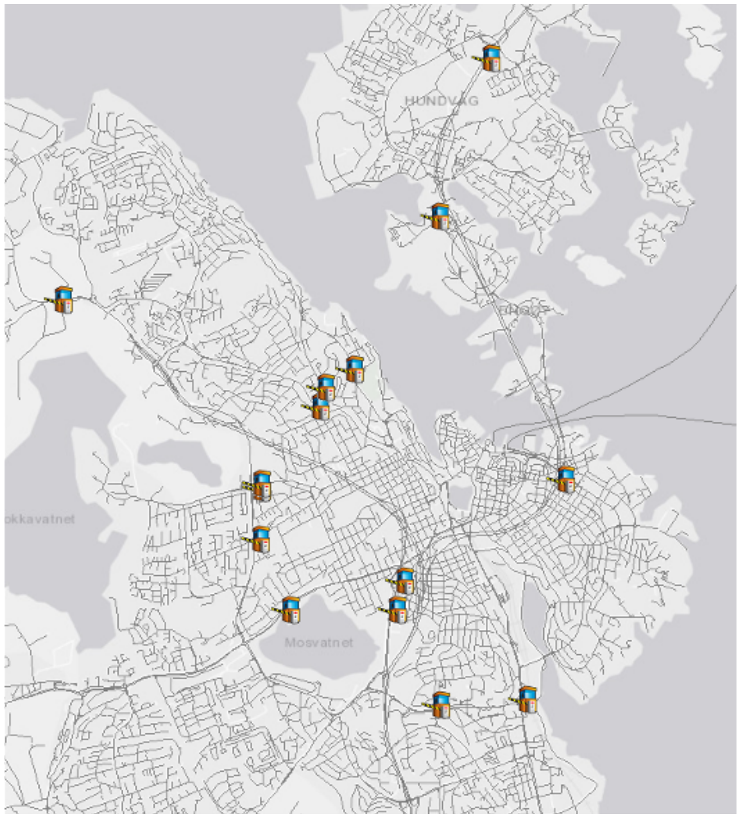


Figure 4.10–Registration of toll stations near the city center (own figure, data collected from ferde.no)

The areas most sensitive to this change would be right on the outside the toll stations on the entry to the city center, and outside the 1 km limit (see *figure 4.11*) where people are inclined to use the car instead of walk (Denstadli & Hjorthol, 2003).

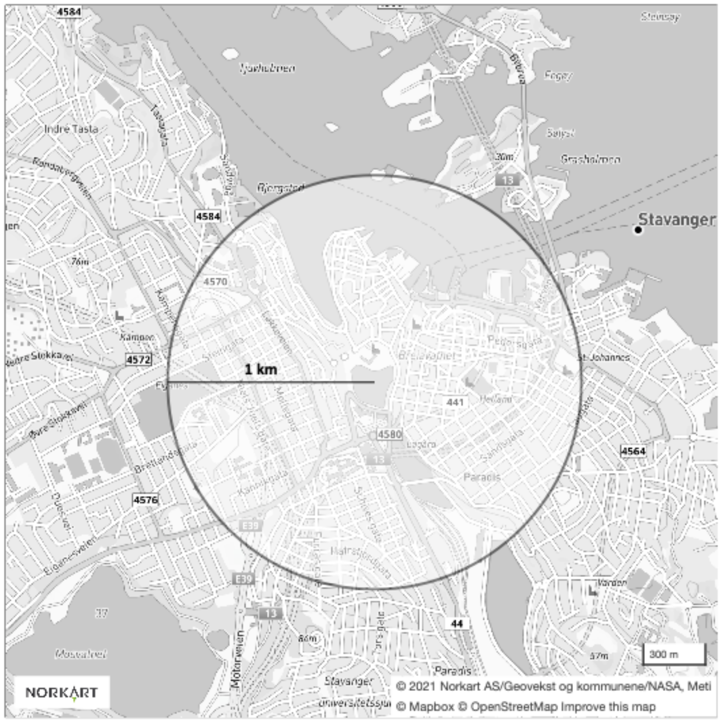


Figure 4.11–1km radius from the city center (source: kommunekart.com)

The analysis maps of the catchment areas treat all three facilities (shopping malls) equally weighted when in fact, and based on the literature review, vitality of a city (or mall) is what gives it its competitive advantage. Where the 4006 postal code of the city center has a sum of 305 businesses in 11 different business categories, Hillevåg (Kilden Mall's postal code of 4016), has 136 businesses in 9 categories, and Madla has 89 and 8 respectively (see *figures 4.12 and 4.13)*.

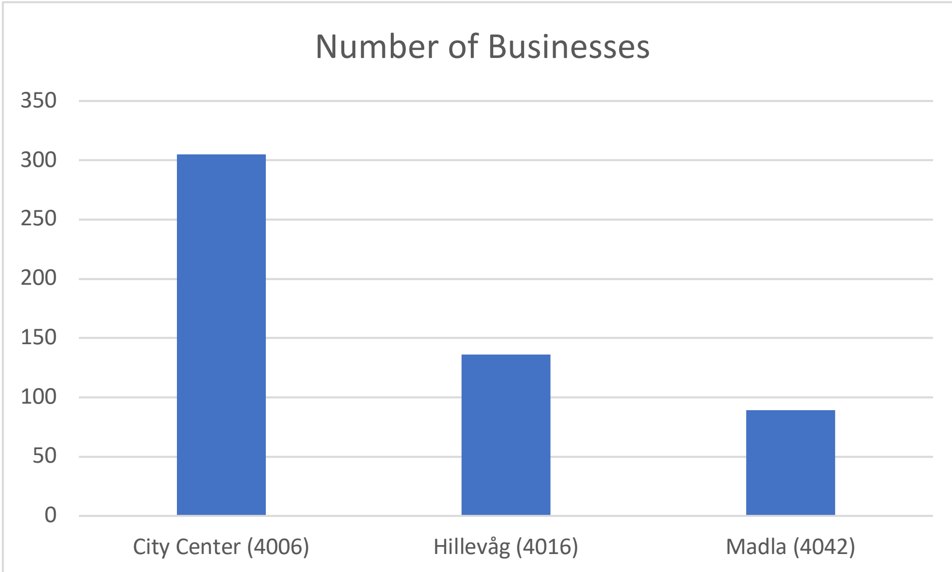


Figure 4.12–Number of businesses (own figure, data from SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

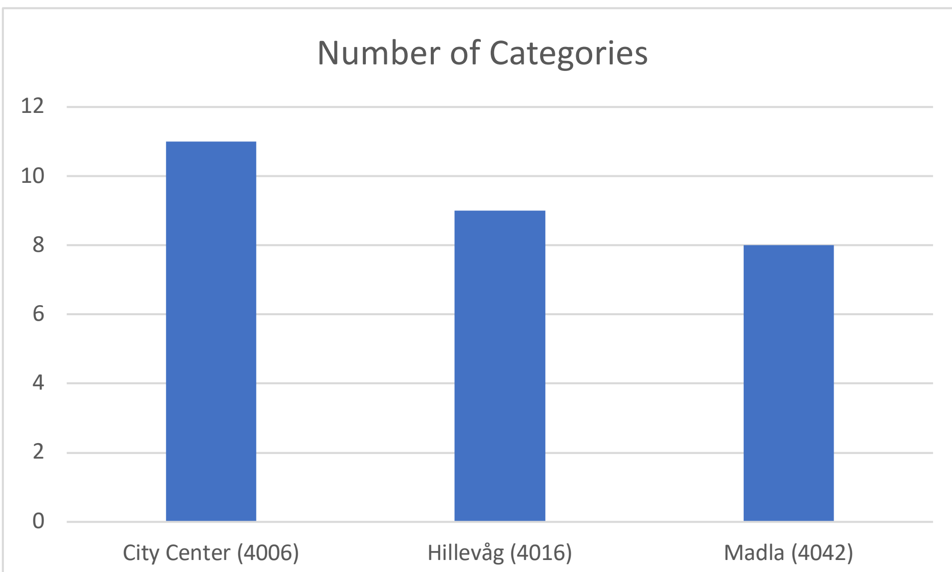


Figure 4.13–Number of business categories (own figure, data from SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

The high number of stores and services gives the city center, and Arkaden Mall located right in the middle of it, an increased vitality and competitive advantage. This then makes the smaller city center catchment area for car users less significant because they are not in reality weighing the same when it comes to vitality. And when it comes to retail, Stavanger City Center has the biggest market share compared to Hillevåg and Madla (see *figure 4.14*); however, when it comes to hardware, Stavanger City Center has seen a dramatic drop in market share since 2009 (see *figure 4.15*).

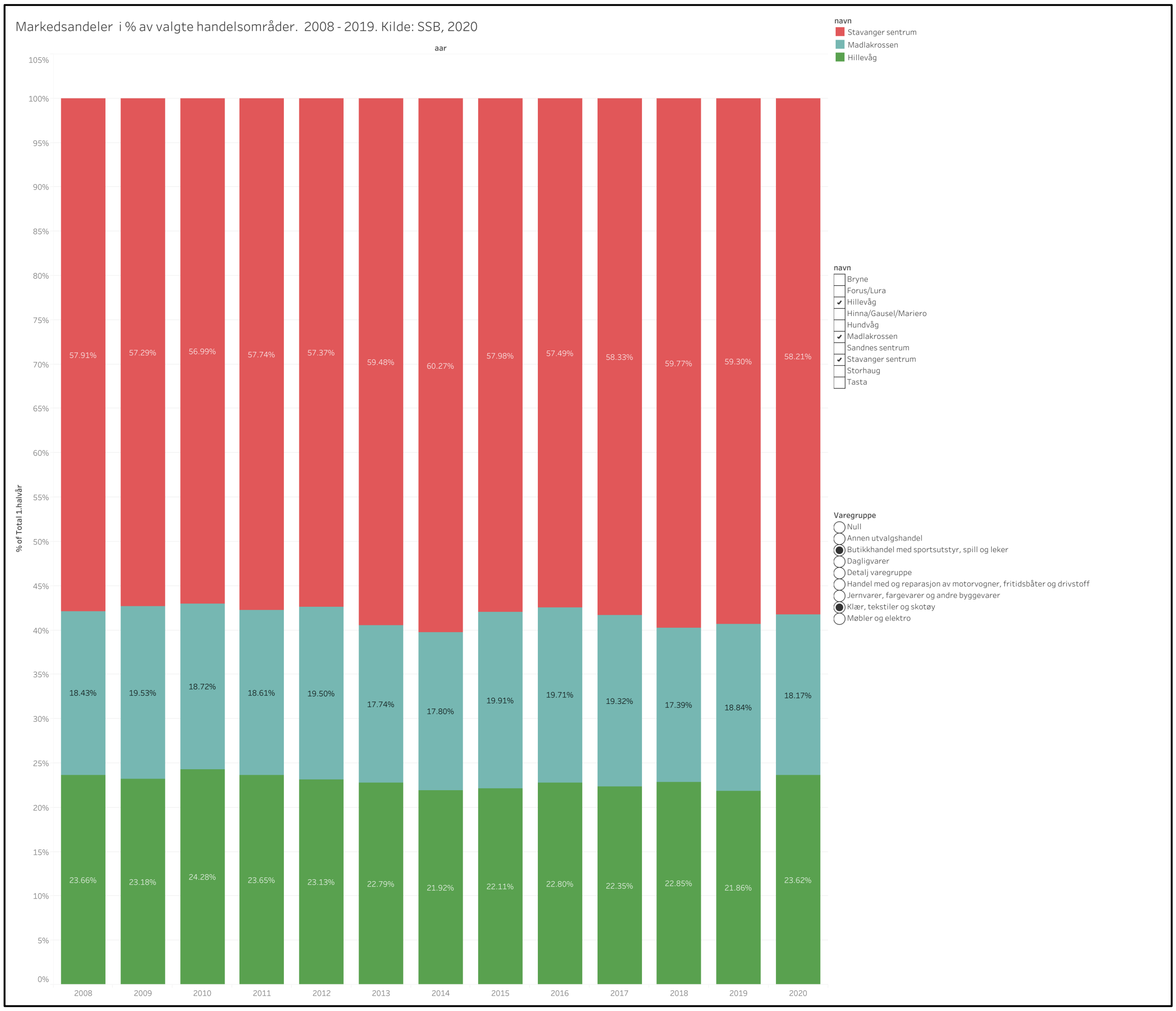


Figure 4.14–Retail market share distribution (own figure, data from SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

Figure 4.15–Hardware market share distribution (own figure, data from SSB, via https://public.tableau.com/profile/stavanger.statistikken#!/)

With the city center's dramatic drop in hardware market share since the early 2010s, Madla's is non-existent, and Hillevåg takes 100 percent hardware market share.

5. DISCUSSION

This chapter discusses the results and elaborates on the implications in a broader context and based on conclusions from the literature review.

5.1 Accessibility Divide in Stavanger

The goal of creating a vibrant and attractive city center in Stavanger is a worthy endeavor and a complex process that requires sacrifices and growing pains. The municipal sub-plan and its proposed projects will impact travel time (for cars) to the city center. Does increased accessibility for some have to mean decreased accessibility for another? The pedestrianization of downtown areas often results in an increased level of accessibility for pedestrians who live, work and play in that same area, while motorists often experience toll roads, lane closures, slower speeds, traffic calmers, and one-way streets. Whether or not this is a fair price to pay for a greener transportation plan might be the wrong question to ask, as there's very little about climate change and polluted environments that is fair. However, knowing the direction cities are going, and what forms of fuel-, transportation-, and land use policies cities are moving away from, cities ought to try to make the transition as effective and as possible.

The results clearly showed an increase in travel time and a decreased service area and catchment area for the city center of Stavanger. Cars provide a form of regional accessibility for people in the periphery of the urban development zones that do not have the same level of public transportation service as central locations. Regional accessibility is important for Stavanger's role as an economic and cultural center of Rogaland county, and should be considered when prioritizing green modes of transportation.

With the implementation of plans that change the road network access in the city center, the transportation component of accessibility is affected by an increase in travel time. This in return decreases the car accessibility for everyone. For people in areas with frequent transit service and within walking or biking distances of the city center, these changes will most likely increase the attractiveness of the urban environment and experience; however, accessibility in general might decrease for people outside the transportation corridors and the prioritized city development zones. The good intentions with creating priority zones for development and transit modes could create a separation between two groups who both rely on the Stavanger as a significant administrative-, economic- and cultural center, but both groups will experience this prioritization differently. While people in central locations might experience these changes as a positive reinforcement of choosing more sustainable modes of transportation, the people who depend on cars for transportation might experience more of a negative reinforcement where they experience more of the negative effects of these projects without experiencing the positive effects to the same degree. The transportation mode change for people living in the transportation corridor is a reasonable and justifiable; however, for people living in the periphery of the urban development zones, that seek the opportunities that the city center has to offer, with limited access to convenient public transportation connections, are the ones vulnerable to this change. As 55 percent of residents in the region live in the urban core (Stavanger Kommune, 2019), 45 percent fall outside of this area. The low-density land use in the region overall simply does not meet the requirements for everyone to have the same level of public transportation service. So while densifying in the city zones, promoting walking and biking, and encouraging public transit over personal vehicle use, it is undoubtedly important to consider the separating effects this has on the rest.

5.2 Competitive Advantage of the City Center

Stavanger loses catchment area to nearby commercial agglomerations such as Madla and Kilden, which means that said agglomerations become the closest facility in areas where Arkaden is the closest facility today. The concern that the increased travel time, resulting in a decreased catchment area for the city center is threatening the competitiveness of the city center is most likely an unnecessary concern compared to other challenges facing the competitiveness of today's downtowns. Even with online shopping trends and the suburban shopping malls, the intraurban hierarchical structure remains strong, and the urban atmosphere and vitality of city centers is bigger than shopping alone (Hatz, 2006). The Stavanger city center offers more than the commercial competition (Madla and Kilden) and an increase in travel time or even the cumulative effects of the cost of parking, toll roads, new traffic patterns, will not weaken the competitive advantage of the urban vitality the city center has to offer. In fact, a walkable and more pedestrian-scale downtown will most likely add to the attractiveness and urban atmosphere that the visitors seek by coming to the city center. The authenticity and organic nature of the city center of Stavanger cannot be replicated in a suburban setting, and as long as the downtown area stays vital, it will have its competitive advantage over nearby shopping agglomerations.

6. CONCLUSION

This chapter concludes the impact assessment by answering the thesis questions based on the findings and discussion.

Q1 "How will the new municipal sub-plan impact travel time and car accessibility for visitors driving to Stavanger City Center?"

The analysis revealed that visitors driving to the city center will see a one- to two- minute increase in travel time after the implementation of the recommended plans in the municipal sub-plan. Visitors originating east of the city center (including Hundvåg) saw the smallest increase in travel time of up to one minute, while the rest saw an increase in travel time of up to two minutes.

Due to accessibility's complex definition, this thesis can only conclude on travel time as part of the transportation component of accessibility. It is also important to remember that the impact on travel time to the city center was assessed using one destination (Arkaden Parking) and does not comprehensively represent accessibility to the city center as a general destination. However, the municipality's plans to strengthen the city center's role as the region's most important city center (Stavanger Kommune, 2019) could in fact, should accessibility decrease, weaken its role by the decentralizing effects of its "green mobility" goals. It all depends on where the municipality draws the line for its sphere of desired influence and reasonable accessibility.

Q2 "How will it affect competitiveness of the city center?"

With increased travel time, the analysis showed a reduced catchment area and it was evident that catchment area based on travel time by car was lost to Kilden and Madla; however, it is impractical to attempt to predict a possible change in people's shopping behaviors based on the findings of this thesis. Although travel time is the main variable in differentiating between route-choice behavior (Harder, Bloomfield, Levinson, & Zhang, 2005), the vitality of the city center provides a competitive advantage that realistically ought to outweigh the effects of the increased travel time.

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LIST OF FIGURES

Appendix

PROSJEKTNR	VEGSTREKNING / OMRÅDE	TYPE TILTAK
1	Øvre Holmegate	Gågate
2	Breigata og Kirkegata nord	Gågate
3	Valberggata	Gågate
4	Olav Vs gt - Jernbaneveien - Kongsgata	Bussvei og sykkelvei.
5	Kannikgata - Madlaveien	Bussvei.
6	Lars Hertervigsgate	Sykkelfelt.
7	Arne Rettedalsgate	Miljøgate/utvidelse fortau. Sykkelt og samlevei bil.
8	Løkkeveien; Kannikgata - Arne Rettedalsgate	Miljøgate.
9	Bergelandsbrua - Birkelandsgata	Ny veiforbindelse. Sykkel og fotgjenger ikke avklart.
10	Bergelandsgata	Sykkelprioritering/sykkelfelt og utvidelse fortau.
11	Kongsgata	Kollektiv-, sykkel og fotgjengergate
12	Klubbgata	Kollektivgate og sykkelgate.
13A	Verksgata vest; Klubbgata - Langgata	Bussprioritering og sykkelfelt.
13B	Verksgata øst; Langgata - Hermetikkgata	Kollektiv- og sykkelfelt. Holdeplass/terminal for by- og regionsruter.
14	Langgata	Sykkelfelt
15	Pedersgata øst; Langgata - Harald Hårfagresgate	Sykkelfelt og utvidelse fortau.
16	Ryfylkegata	Kollektiv- og sykkelgate.
17	Kjelvene/Ryfylkegata	Ny sykkel og gangforbindelse.
18	Paradisadkomst; Lagårsdsveien - Paradis	Samlevei bil , ny adkomst.
19	Havneringen/Holmen	Snuplass/holdeplass
BU1	Holmen - utbygging	Utbygging av ny sentrumsbydel
BU2	Holmeallmenningen – nytt byrom	Omforming av p-plass til byrom(G5), rekkefølgekrav
BU3	Børehaugen torg – nytt byrom	Omforming av p-plass til byrom (G7)
BU4	Kjeringholmen	Opprusting og utvidelse av eksisterende byrom(G4)
BU5	Jorenholmen – nytt byrom/bebyggelse	~~Flytting av p-anlegg til Fiskepiren.~~
BU6	St. Svithuns gate - nytt byrom/bebyggelse	Omforming av p-plass til byrom(G33), rekkefølgekrav
BU7	Prestegårdshaugen – nytt byrom	Omforming av p-plass til byrom(G28), rekkefølgekrav
BU8	Stavanger stasjon – utbygging	Omforming av p-anlegg til bebyggelse og byrom
BU9	Nytorget – nytt byrom	Omforming av p-plass og vei til byrom(27)
BU10	Strandkaien	Omforming av p-plass til byrom (G8)
BU11	Ajaxparken, utvidelse byrom	Omforming av p-plass til byrom (G2)
BU12	*Indre Vågen, Kongsgårdbakken – P-Valberget*	*Utvidelse byrom, torget, til Skagenkaien indre del. 1 års prøveordning*

Figure A.0.1–List of projects for Stavanger City Center (source: Stavanger Kommune)